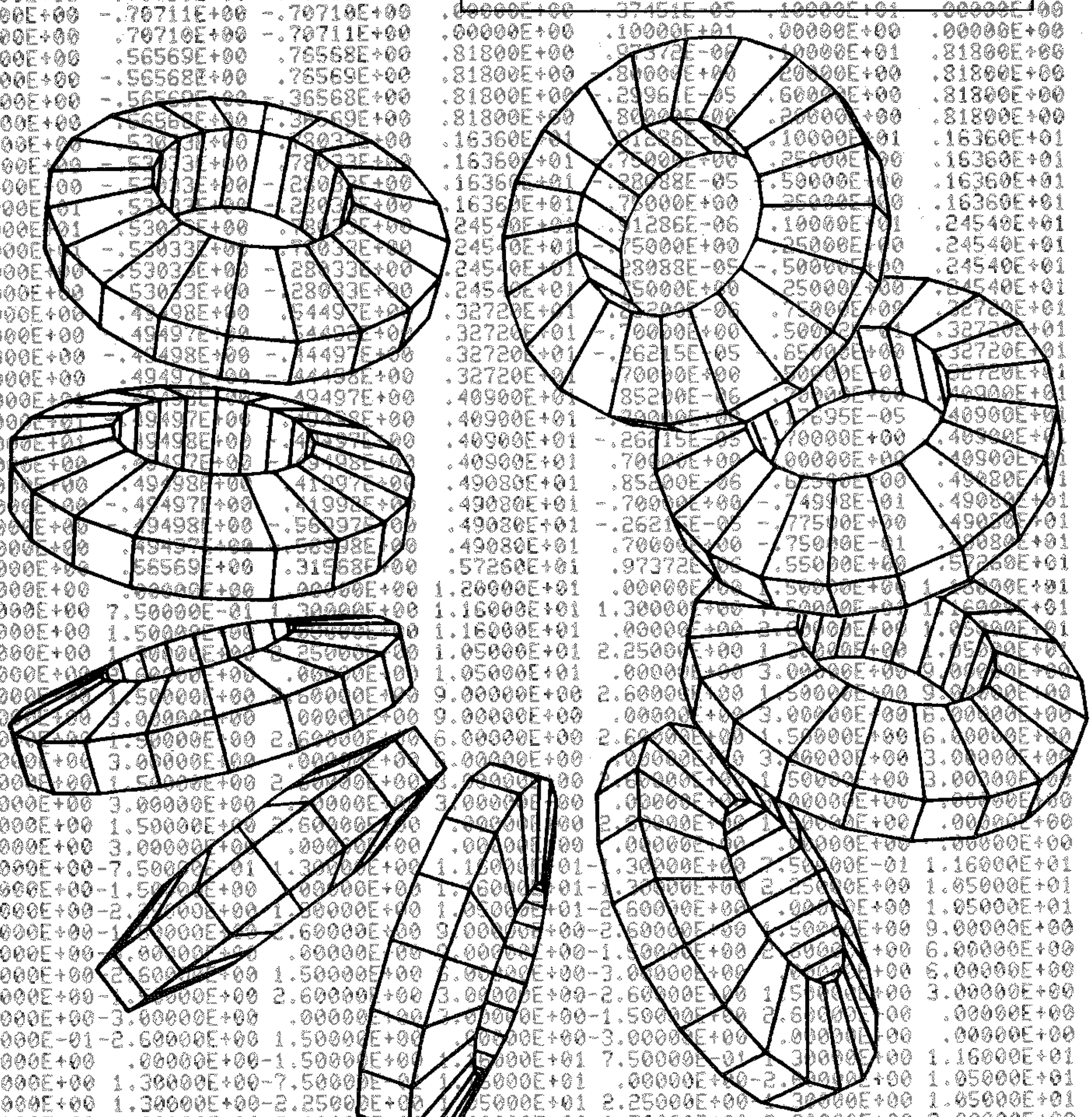
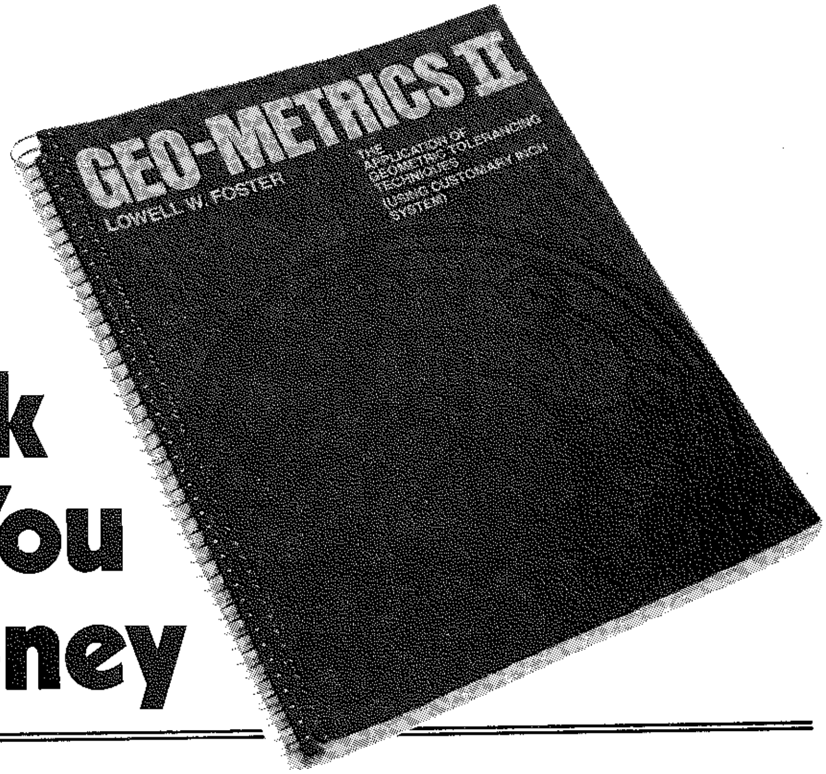
METRIC

ENGINEERING DESIGN GRAPHICS JOURNAL

WINTER 1981 VOLUME 45 NUMBER 1





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ENGINEERING DESIGN GRAPHICS JOURNAL

CALENDAR

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1981 - University of Southern California
Los Angeles, June 22 - 25

1982 - Texas A & M University
College Station, June 21 - 24

1983 -

EDGD MIDYEAR CONFERENCES

1981 - The University of Louisville
Louisville, KY

1982 - California Polytechnic Univ.
Pomona, CA

ENGINEERING DESIGN GRAPHICS JOURNAL is published - one volume per year, three numbers per volume, in Winter, Spring, and Fall - by the Engineering Design Graphics Division of the American Society for Engineering Education, for teachers and industrial practicioners of Engineering Graphics, Computer Graphics, and Design Graphics, and Creative Design.

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ENGINEERING DESIGN GRAPHICS JOURNAL OBJECTIVES:

The objectives of the JOURNAL are:
1. To publish articles of interest to teachers and practitioners of Engineering Graphics, Computer Graphics and subjects allied to fundamentals of engineering.
2. To stimulate the preparation of articles and papers on topics of interest to its membership.
3. To encourage teachers of Graphics to innovate on, experiment with, and test apprpriate techniques and topics to further improve quality of and modernize instruction and courses.
4. To encourage research, development, and refinement of theory and applications of engineering graphics for understanding and practice.

DEADLINES FOR AUTHORS AND ADVERTISERS

The following deadlines for the submission of articles, announcements, or advertising for the three issues of the JOURNAL are:
Fall . . . . September 15
Winter . . . . December 1
Spring . . . . February 15

STYLE GUIDE FOR JOURNAL AUTHORS

The Editor welcomes articles submitted for publication in the JOURNAL. The following is an author style guide for the benefit of anyone wishing to contribute material to the ENGINEERING DESIGN GRAPHICS JOURNAL. In order to save time, expedite the mechanics of publication, and avoid confusion, please adhere to these guidelines.

1. All copy is to be typed, double-spaced, on one side only, on white paper, using a black ribbon.

2. All pages of the manuscript are to be consecutively numbered.

3. Two copies of each manuscript are required.

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REVIEW OF ARTICLES

All articles submitted will be reviewed by several authorities in the field associated with the content of each paper before acceptance. Current newsworty items will not be reviewed in this manner, but will be accepted at the discretion of the editors.

NOTE: The editor, although responsible for copy as it is published, begs forgiveness for all typographical mistakes, mis-spelled words and any goofs in general. Typing is done mostly by non-professional word processors who either are still in high school or are not trained in professional word processing. Thank you for your patience.

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Engineering Design Graphics Journal

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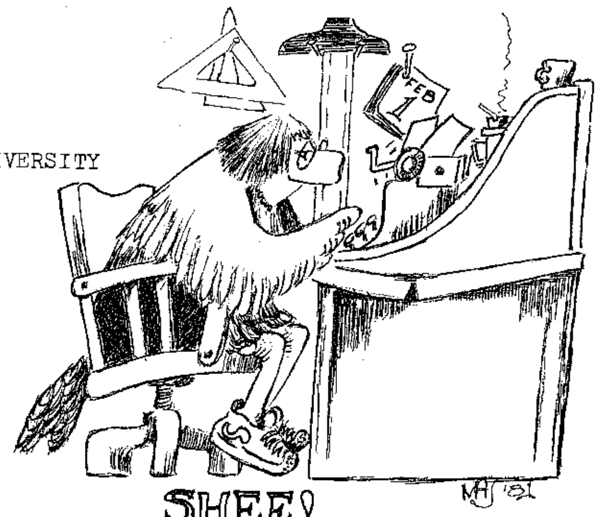
EDITOR'S PAGE

MARY A. JASPER
EDITOR, EDG JOURNAL
MISSISSIPPI STATE UNIVERSITY



SHEE!
(with apologies to SHOE)

It is certain that the reader cannot fail to notice the "image"reproduced in the upper right hand corner of this page. Credit for the idea must be given to the artist who creates the comic strip "Shoe"; only the name, "Shee" (pronounced "Shee-ee-eee!"), has been changed to protect the editor.

****

The cover, also, is the original work of John Jensen, Marquette University, who kindly offered his services and idea for this issue. Jensen's statement concerning the evolution of this cover will be of interest to all of our readers, and it is quoted as follows:

> "As I was trying to decide what to do, many ideas went through my mind. Most of those ideas related to how complex and impressive a thing I could produce. Then I began to ponder over what is computer graphics? (Most of us are still stuck on this one question.-Ed.) and howis it significant enough to be on a journal cover? Late one evening it came to me! Suddenly complexity was not the key but simplicity was. I can recall being affected by an excellent article written by Dr. Charles Newlin in the Spring 1979 issue of the EDG Journal. In that article, among other things, he discussed computer graphics and the misconception about the decreased need for training in graphics. On page 21 he stated; 'The advent of computer graphics has simplified the engineers' work because it eliminates the need to make the mental conversion from numbers to graphics.'
>
> "Therefore, my design includes a cover completely covered with numbers generated by a graphics file. Printed over the top of the numbers is a simple ring generated and animated using MOVIE.BYU - signifying the visualization of those numbers."

Jensen's article on the use of computer graphics and computer aided instruction also appears in this issue.

****

The theme of the midyear meeting could have been "Computer Graphics", as nearly all of the presentations had to do the this "fair-haired" offspring of engineering science, or engineering technology -- choose the one for the side of the fence on which you sit.

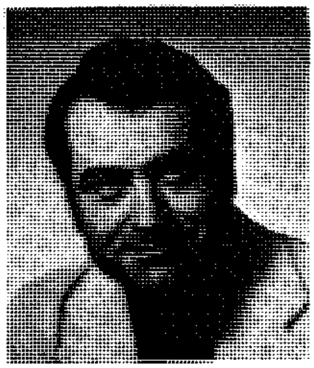
'Most every college, university, technical institute, junior college, trade-school and day care center is either "into" computer graphics or wishes for the great "equipment fairy" to leave some CPU's, CRT's, digitizers, line printers, plotters (etc.) under their pillows at night. Almost all of us are aware that equipment does cost money, and unless proposals are written the "equipment fairy" doesn't come. Some of you will see the analogy here of "pulling eye teeth".

Therefore, most of this issue is devoted to CG, as is evident from the table of contents on the preceding page. The last two articles in the section by Mosillo and DeJong could be taken as "point/counter-point" fare; this is not to say that Mosillo is not for teaching traditional methods of visualization, or DeJong is a proponent of a massive "short-out" in all CG equipment, but I believe that both sides of the issue are presented in a readable and articulate manner and that the reader will enjoy these two points of view.

****

Coming up in the next issue will be results of the midyear meeting survey conducted by Pete Miller, Larry Goss' Oppenheimer Award winning presentation on consulting in Graphics, and another "Gestalt"-type graphics masterpeice from our good friend Reinhard Lehnert in West Germany. Add to these some exercises in Descriptive Geometry from Land and Rotenberg, the second article in the series by Raethe on graphical solutions in structural analysis, and some other studies in Graphical Methodology, the Spring issue of Volume 45 should be something for all of us to look forward to.

CHAIRMAN'S PAGE



PAUL S. DE JONG
DEPT. OF FRESHMAN ENGINEERING
IOWA STATE UNIVERSITY
AMES, IA

"REGISTER OR PERISH?!?"

Your able editor informs me that elsewhere in this issue you will find a short article sans illustrations - based on my paper at Williamsburg, arguing against computer graphics as a panacea for graphics' ills, a position which may seem futile in view of developments around the country. Maybe I should re-read Don Quixote.

At that Williamsburg conference, the Division voted to endorse and seek the support of NSPE for a statement that graphical competence is requisite to the practice of engineering. You would surely agree with that, but the question of NSPE's support brings to mind the other question of professional registration. Since I have a tendency to joust with steamrollers, I feel compelled to address this one.

As you may know, Iowa has a landmark recertification law requiring professional development to maintain one's license. As a part of the annual report, one's time spent in practice must be reported; teaching is considered "practice" for the purposes of license renewal.

The law clearly requires that an engineer must be licensed to practice for the general public - which we do, and are so credited, but registration is not required of us. If we don't practice for (and on) the public, no one does!

Deans generally resist the move to mandatory registration, which is understandable; anything of a mandatory nature is frowned upon in academia. Professors too, often resist registration, but on the basis that there is no competency review. This argument doesn't hold water, because there was never a provision for recall or refusal to renew a Ph.D. either. I have always had a visceral feeling that those using this argument are trying to conceal a lack of faith in their own "field" experience, having proceeded directly to the doctorate and into research/teaching. They also underestimate themselves.

With conditions as they are today, I am concerned that many state legislatures, casting about in search of ways - good or bad - to economize, may sieze upon this contradiction and use it to our great disadvantage. Moreover, sooner or later some public-minded individual or organization will - and probably should - press registration upon us, regardless of their cause.

When that day comes, will you be ready? A growing number are, but it may well be that the survival of engineering schools will depend on our ability to point to our faculties as 100 percent qualified, as are the faculties of medical and law schools today. If it were not for those qualifications, and corresponding salary schedules, their staffs would leave for greener pastures immediately. That day may not be far off for us, either.

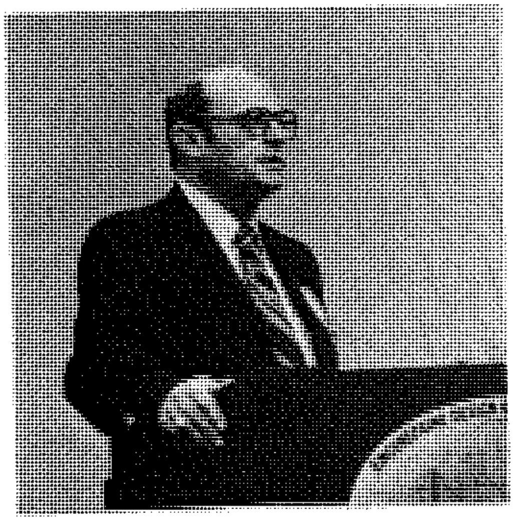
Let's talk more about it at USC in June. I hope we'll see you there!

Paul S. DeJong, P.E.
Chair
EDGD

ENGINEERING DESIGN GRAPHICS DIVISION
MIDYEAR MEETING
1980
WILLIAMSBURG, VA

Photographs by Margaret Eller
and Larry Goss

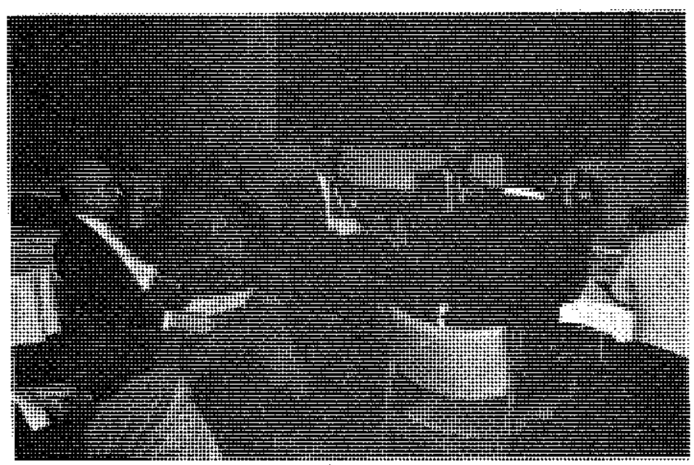
The Group Picture of Participants and
Spouses (Spice?), courtesy of L. Goss

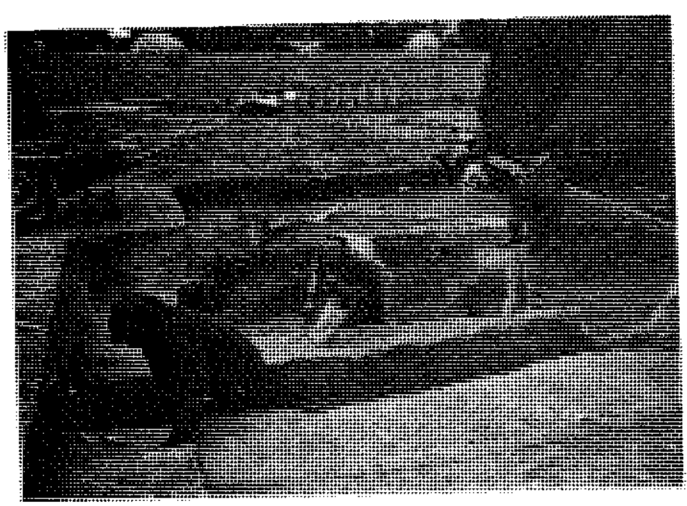


Host for the Midyear Meeting "Bud" Devins Welcomes the Group.

Program Chairman for the meeting, Jon ("Yon") Duff with opening remarks.

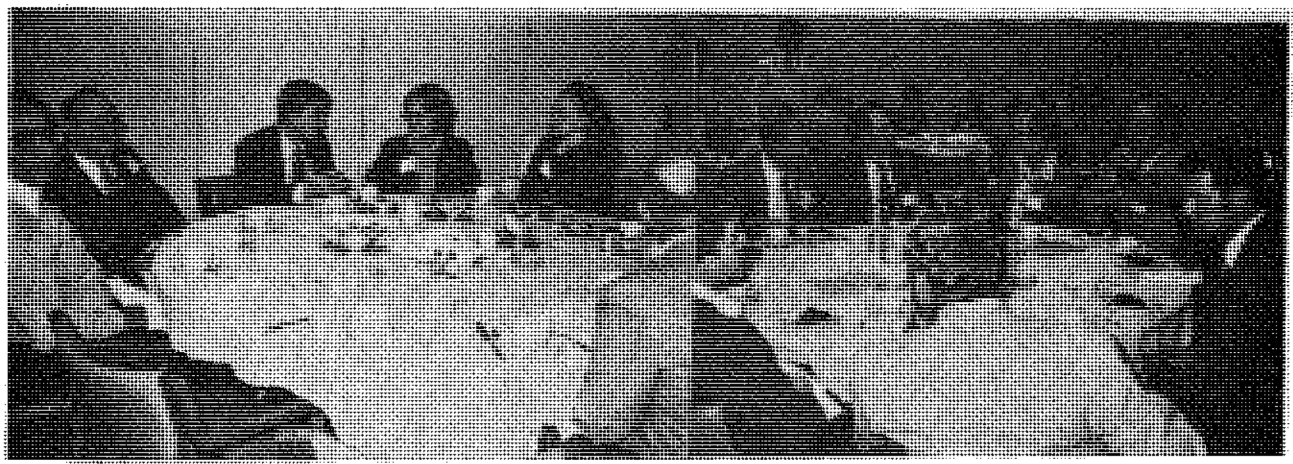
The Executive Committee Executes!

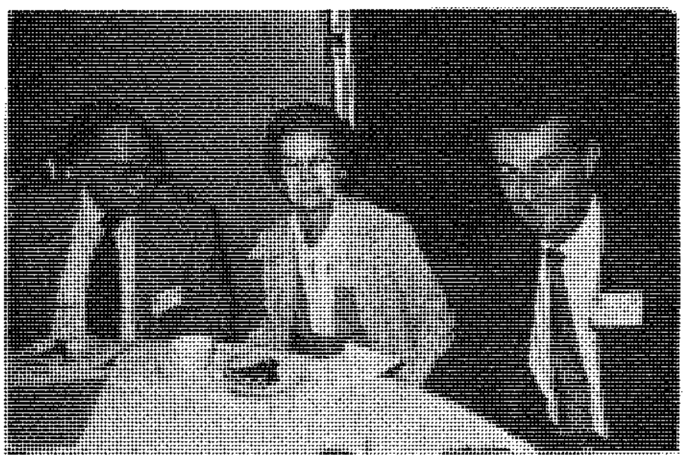




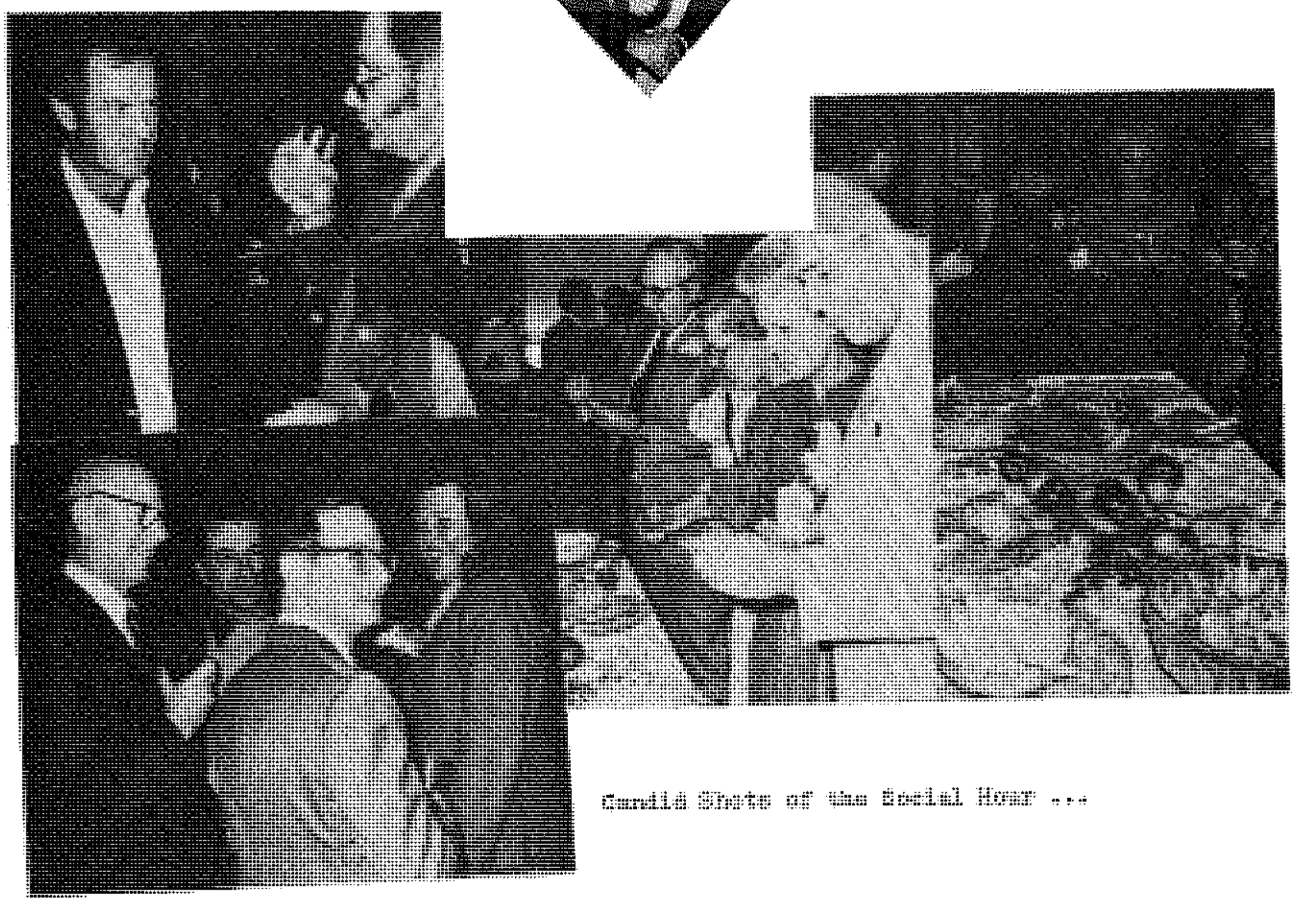
... At the "Digs"
A portion of the archaelogical exploration at Williamsburg to uncover the first insane asylum in the "New World". An exercise in <u>Solid Geometry</u>.

Business at the Business Luncheon ...

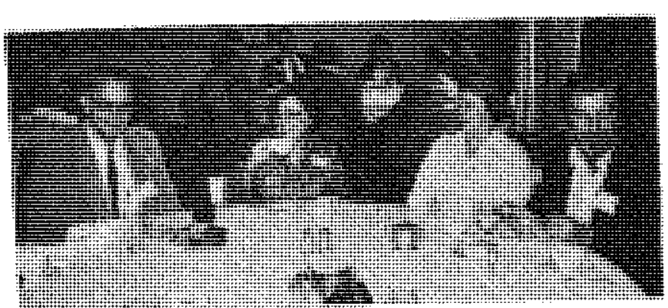




Larry Goss, winner of the Oppenheimer award for his paper "Consulting in Graphics - Good for the Instructor and Good for the Student" accepting the check from Klaus Kroner.

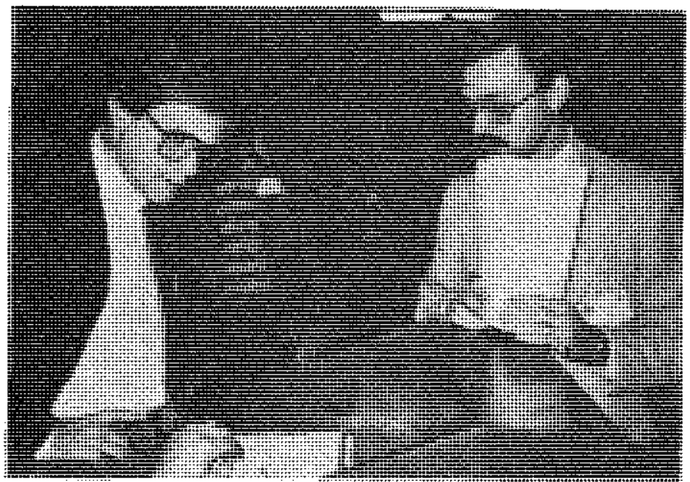


Candid Shots of the Social Hour ...



Luncheon with the Ladies ...

Between the Sessions ...



from the midyear conference

COMPUTER GRAPHICS IN FRESHMAN ENGINEERING PROGRAMS

--When, Where, How, & How Much??

Daniel L. Ryan
Clemson University
Clemson, South Carolina

SUMMARY

Computer-aided engineering graphics has been incorporated into a second three-semester-hour course which takes the first year student beyond the first course on engineering graphics. The computerized graphical procedures, which are most useful to the engineering student, are presented in a simplified language. Numerous examples are taken from mechanical, electrical, and civil engineering. The guiding principle of the course is application: automated design methods and hardware consideration are presented. The course gives ample coverage to the frequently encountered type of problem that necessitates a combination of automated and manual solution methods. Moreover, emphasis is given to the existing automated and computer-aided graphics programs rather than to the procedures for writing new ones. At the same time, however, the computerization of several heretofore manual methods are pioneered in this course.

INTRODUCTION TO FRESHMEN?

A lot has been written about the computer and its role in traditional freshman engineering programs across the country -- now some fool wants to include computer graphics for freshmen, you ask! Yes, that is what the man said, "Human beings are smart, creative and slow, while the computer is stupid, uncreative and very fast," says the writer in chapter 1 of his new book Computer-aided Graphics and Design. The challenge is to take advantage of the strengths of each, to improve the efficiency of both.

Therefore, computer-aided engineering graphics should definitely be introduced during the freshman year. Ideally a two course 2(1,3) sequence should be provided. The first course should include up to 12 units of study for a semester. Eleven should contain modern engineering graphics concepts taught with current industrial practices and equipment. The 12th unit should be an introduction to "computer graphic". Any engineer or designer -- whether of machine parts, highways, or electrical systems -- knows what it is like to re-draw an entire set of plans because of design modifications. Computer graphics can take a lot of the drudgery out of such work, but computer graphics is also changing and improving the design process itself, often in very subtle ways.

At Clemson and many other colleges this course is taken concurrently with a programming language course. The first course should contain as little programming as possible. The second course 2(1,3) dealing with computer graphics should merge topics like descriptive geometry with an introductory statics approach using computer graphics output in problem solutions. Graphics programming techniques should be part of this course.

COURSE OR COURSES?

During the last year or two a renewed energetic discussion has grown up around the need for a single course or a sequence of courses to best introduce interactive computer graphics for CAD/CAM. To some this has meant, "Let the human do the design and the computer will carry out the graphics",with the tacit assumption that somehow this could be done by some other courses usually not specified.

These other courses, clearly begin at the fresh man level. An ideal approach would be the two just outlined followed by:

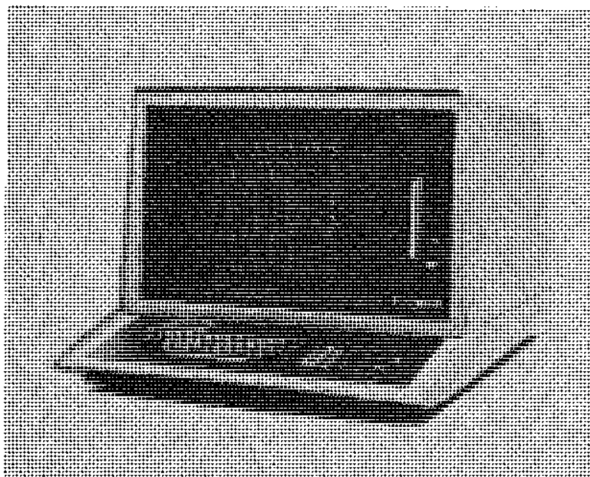
3. separate 3 credit course at 300 or 400, and
4. design course using computer graphics.

The interactive graphics taught at Clemson contain the above four courses plus one graduate course in computer graphics for electrical engineers.

At the freshman level, a sucessful course will begin with familiar topics and progress to the abstract computer applications. Most of us here remember the chapters on creative design in most engineering graphics textbooks which outline; "Students, if you will state your problem clearly, we will organize it quickly and give you the answer inexpensively." The trouble of course is very few "real world" problems are stated that clearly. We need to use a computer in this early formulative stage as well as in the solution stage of a design. The aim of freshman engineering/computer-aided graphics and design is to relieve this open-ended and difficult situation by putting the user in close touch with the computer. By providing the student with a tool (computer) and language which is natural to his set of problems, perhaps we can avoid this detailed statement of the design problem -- at least we might delay the questions until the student has developed a partial solution.

WHAT KIND OF HARDWARE IS USED?

This type of course can be implemented by an on-line typewriter and a fairly fast computer. However, the impact of such a limited hardware set is fairly low. To appreciate more dramatically how the above course principles can have far reaching



effects on engineering education, consider a student with a CRT. He/she has a light pen to use as a I/O writing tool, a pointing or selecting medium and a keyboard to insert alphanumeric information. By coupling a graphic capability of a human to a machine like a computer, a whole host of applications can be considered.

A freshman engineering student is a prime case of a user who often wants to deal with graphics. The problem of using computer hardware in this field has been limited by two basic short comings in our computer technology.

1. Graphics .... engineering drawings are the worst case.... is a language all of its own. Translating graphics into a computer language by hand is tedious, error prone, time consuming, and normally more difficult than creating the original drawings.

2. Translation of a concept from the designer's mind into graphics is complex. It is a series of intricate steps which eventually converge as a designer brings many individual and sometimes unrelated ideas into the final design.

At Clemson University this hardware/software development work has been carried out under the title "CUPID". At Control Data Corp. a similar system was developed called "digigraphics" and at the Lockheed Corp. a "CADAM" system is used. All of the above hardware systems provide capability such that:

1. The student deals directly in graphic language rather than in an artifical coding language normally associated with computer-based automated devices. The user is not a programmer; he/she is a student designer, engineer, or draftsman. This type of system provides a highly automated tool to permit him/her to work faster, more accurately, and more economically.

2. The student using this system proceeds with the design as always. Now, however, each time a step is taken, the system allows evaluation of the result in relation to what has gone on before.

A good hardware system will also accept graphic data directly. The student enters the data with a pencil-like electronic pen and tablet. To the student, it appears as if the pen is actually writing on the face of the CRT when the pen is brought in contact with the surface of the graphics tablet. Actually, the pen and tablet are giving instruction to the computer, which in turn, is creating a data sequence causing the tube to respond graphically. The computer immediately produces a precise picture of what it understood the student to mean.

Since these graphic representations are immediately available in mathematical digital form, this data can be used by several different types of peripherial equipment. Such equipment includes microfilm devices, storage and retrieval devices, plotters, printer/plotters, and remote monitors.

SOFTWARE/FIRMWARE PACKAGES

The discussion to this point has concerned courses and hardware. Little has been said about computer programs, or software ... the sequence of instructions necessary to logically direct the hardware performance on a FORTRAN or BASIC format. An earlier ASEE-EDG mid-winter paper entitled "Pictorial Image Display from Computer Database" and presented at Mississippi State University contains CUPID software listings.

At the freshman level software may be placed as firmware. Firmware provides the programming instructions (on micro-processor chips) to accept data created by the student (lines, circles, curve, and alphanumerics) and translate this data automatically into digital form. This form is compact and similar to that used in analytical geometry. For example:

1. A line is stored as coordinates of its end points,

2. A circle is a center and radius,

3. A curve is an origin point and the three constants for a conic equation. Other methods of teaching will work, the important thing is that computer graphics be included using one of the methods. If graphics instructors, or engineering professors for that matter, are not including computer applications in their courses, they are doing the student an injustice. Field trips to industry painfully point out that computer processing is a fact of life. We should stop using the excuse that no standards or methods for implementation exist and start developing some. The excuse that computers are expensive is really feeble; most colleges and universities have all the hardware needed for a freshamn level course. The truth is that many of us are afraid to try something new.

WHAT TOPICS SHOULD BE COVERED?

The topics of computer graphics are almost endless depending upon the instructors background and area of specialty. For example, an engineer with undergraduate training in Mechanical, Electrical, Chemical, Ceramic, Industrial, or Civil; teaching a beginning graphics course will cover the basic construction concepts and then present multiview drawings, et al from that specialty. I see no difference in a computer based graphics course; there are still the basics of graphics construction, followed by the basics of computer operation, followed by application drawings.

Let us all remember that graphics is graphics and that is never going to change -- but the methods for producing graphics has already changed in most industries. It is time to catch up again!

PHOTO CREDITS- Tektronix, Inc. Information Display Division.
For more information, please contact:
Melissa Waggener (503) 682-3411
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from the midyear conference

GRAPHIC COMMUNICATION CHALLENGES OF THE SPACE AGE

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JET PROPULSION LABORATORY
PASADENA, CA 91109

PROLOGUE

When I was asked to give this paper I had visions of bringing you the very lates in the solution of graphics problems found in space research. However, much to my dismay, most of the material I am going to present is "old stuff"-- concepts in the presentation of ideas on paper -- that were developed 15 to 20 years ago. The present economic environment in which we now exist stipulates that greater risks be taken in the possible failure of hardware during a mission, therefore, the need for "as lauched" drawings of such things as cable routing, etc., ceased to exist. So, as you watch the pictures of Saturn, sent by Voyager, on the TV screen, you can rest assured the material you are teaching in graphic communication, though polished and honed for a particular need, is still viable.

GRAPHIC COMMUNICATION CHALLENGES IN THE SPACE AGE

As in the engineering of any modern complex machine, many kinds of drawings are prepared in the design of a spacecraft. The vast majority of these are probably of the same format and text used in other industries.

My entire career has been in the aerospace field, so I am at a disadvantage to compare the drawings we prepare to the drawings of other fields of endeavour.

Some things to keep in mind as the following drawings are discussed are:

a) The production requirement for spacecraft is one or two units, so the parts comprising a spacecraft are not necessarily designed for mass production techniques.

b) JPL supports industry and does not compete with it. When we prepare a fabrication drawing, the draftsman or engineer has no idea where this part will be fabricated, so extreme care has to be taken to insure the drawing will be complete and free of error in every aspect.

c) We are now working with various organizations in Europe which could conceivably add to our communication problem. One example I have come across recently is European 1st angle projection, but not true 1st angle projection, for when the views on a print were put together as 3rd angle projection, the drawing was easily read.

The examples chosen for this paper were those that may be unique in design or drafting technique.

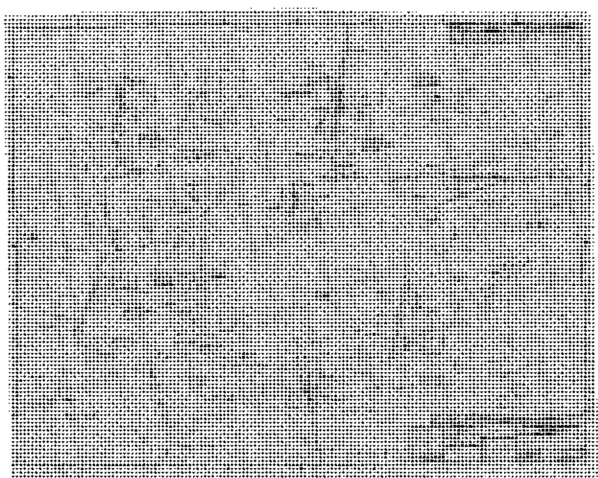
I. GRAPHIC COMMUNICATION OF NECESSITY

Graphic communication of necessity, of course, includes the vast array of fabrication drawings:

- Detail Part drawings
- Standard Part drawings
  - Nuts, bolts, washers, electronic parts, etc.
- Assembly drawings
- Installation drawings
- Layout drawings, which define the parameters of all the component parts of a device or unit

and, let us not forget

- Plumbing and Electrical schematic diagrams
- Printed circuit layouts
- Etc.

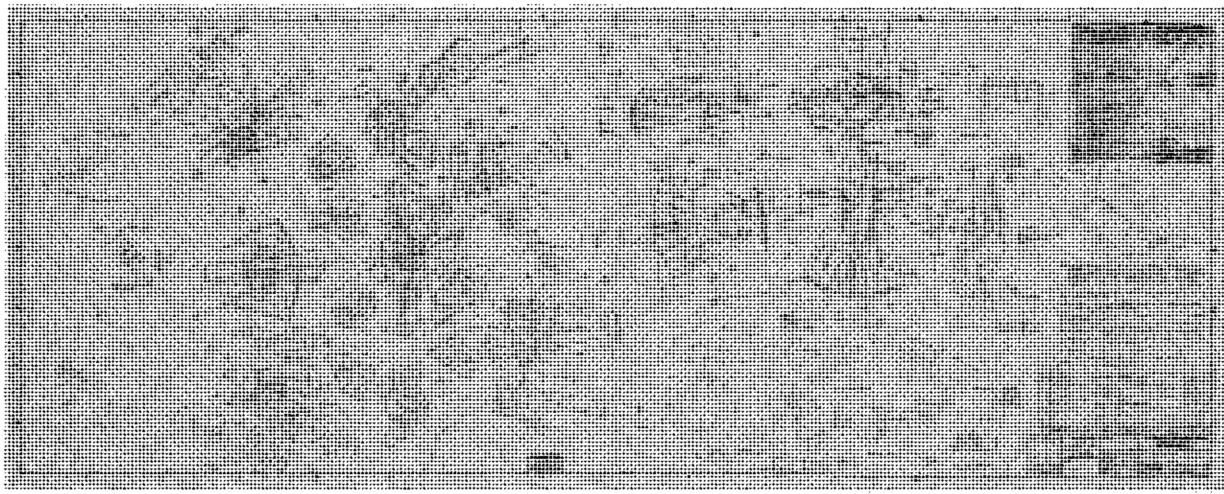


The first example of a fabrication drawing is a propellant tank for the Voyager spacecraft.

The Problem: "How to support the tank and minimize the added weight?"

Design Solution: Provide attachment points in the plane of the cylindrical portion of the tank.

Drafting Solution: Fair attachment tabs into the basic structure to permit increased tank wall thickness without inducing local bending moments. This can readily be seen in detail F, sections R-R, S-S, T-T, etc. One theme that is consistant throughout drawings, is attention to detail. As was mentioned previously, we are very conscious of mass. Twenty years ago we were concerned about grams in a 8.1 kilogram payload. Today we are just as concerned about Kilograms in a 2,500 kilogram spacecraft. Reliability is another concern which also dictates attention to detail.

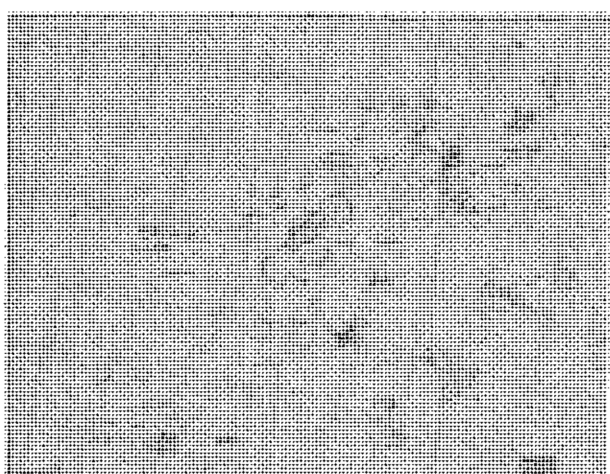


The drawings of the the upper fittings for the spacecraft adapter structure are not unique, but quite complex, requiring a vast amount of descriptive geometry.

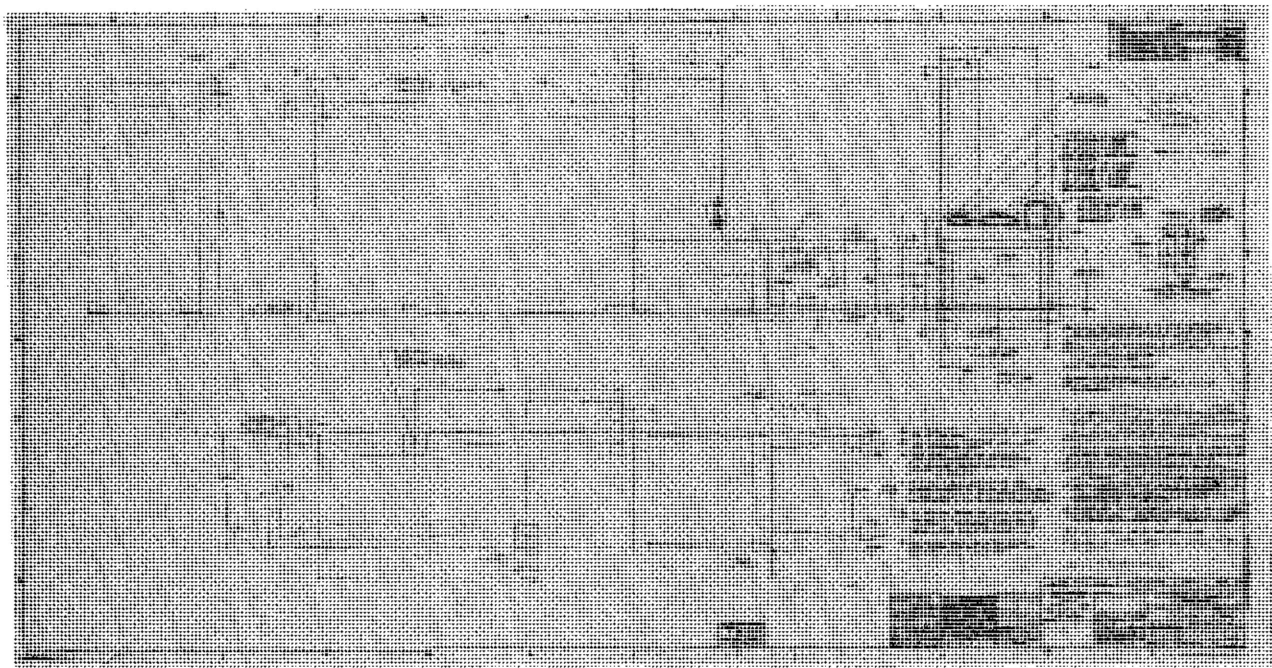
This is part of the primary structure between the spacecraft and the launch vehicle. Four of these fittings carry the launch loads of the spacecraft.

The Problem: "Define the part for the optimization of the fabrication procedures.

Solution: A team consisting of machinist and a design engineer worked together in the generation of this drawing, and in so doing produced this prototype part. A tape was then produced, from the drawing, from which the flight hardware was fabricated, in Wisconsin, without any problems.



These drawings represent the next assembly of the fitting showing its use on the adapter truss. Some of these drawings could be used as descriptive geometry problems by translating some of the dimensions shown.



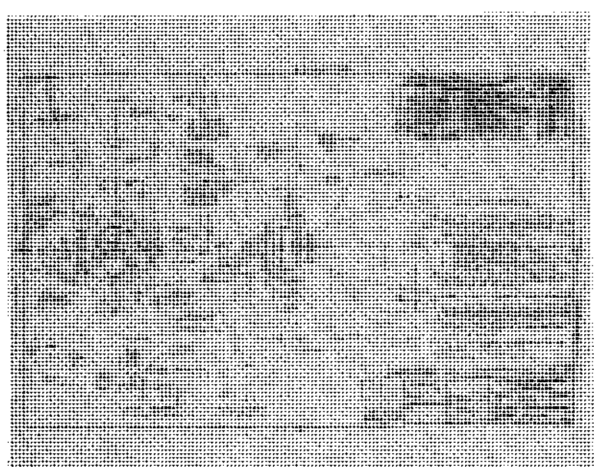
Ultraviolet Spectrometer Assembly with
Interface Control Drawing

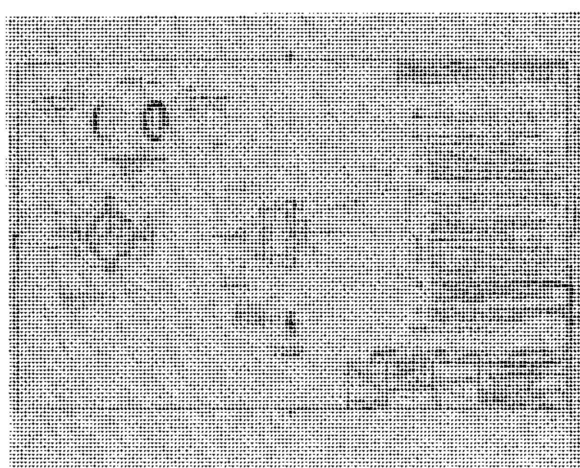
An Interface control drawing may be out of the ordinary for some of you. The function of this drawing is to provide the JPL cognizant engineer and the vendor (of a commercial product or and instrument provided by a University or other laboratory) with the following data:

a) The geometric envelope of the subsystem or part.
b) Mass.
c) Products of inertia.
d) List functional, design, and other pertinent specifications.
e) Known mechanical fasteners, type, size and location.
f) Known electrical connectors, type and location.
g) Hydraulic requirements, if any.
h) Thermal control requirements.
i) Anything else not covered above.

It is to be noted here, that all of these parameters are subject to negotiation by both parties. In addition, this type of drawing may get international distribution as some of our scientific instruments come from England, France, West Germany, and Japan.

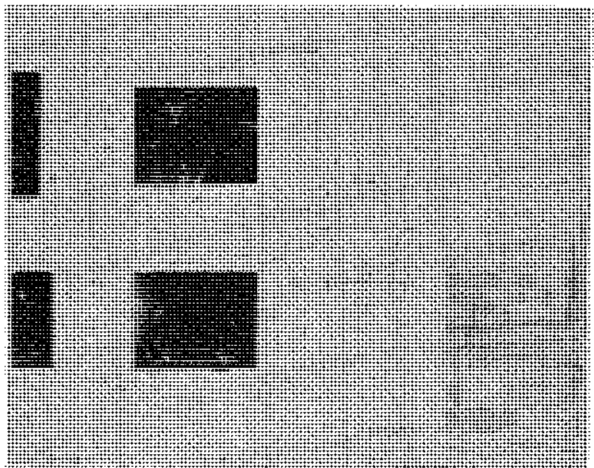
The next two drawings are interface control drawings of the Rocket Engine Assembly 300 lb. Thrust.





II. GRAPHIC COMMUNICATIONS OF CONVIENCE

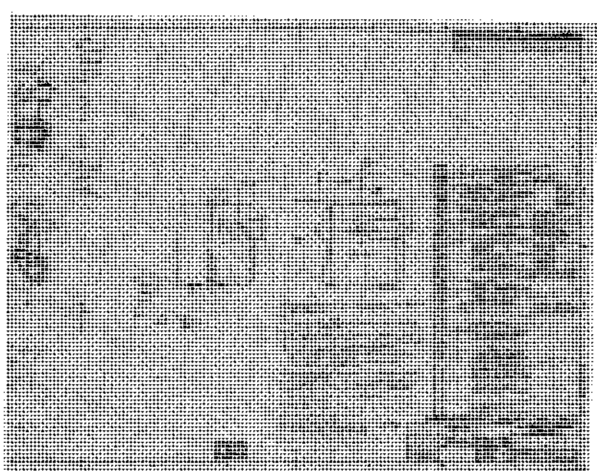
Graphic communications of convience are those drawings which are prepared to fill a unique requirement, at least unique to us at JPL. Three examples of this type of drawing will be discussed.



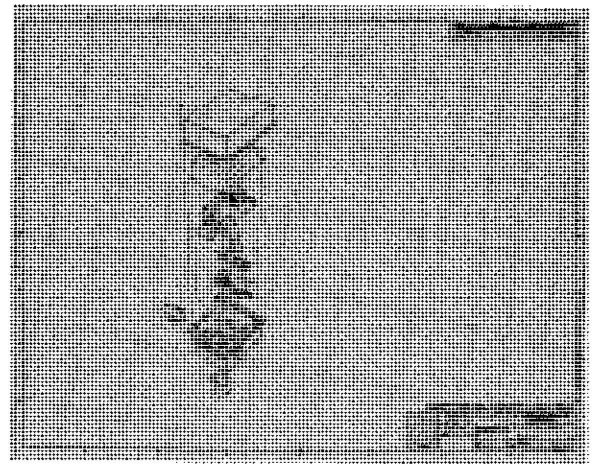
Cable, Forward Structure, Installation

In the past we had a series of flights on the same mission, i.e., lunar exploration, such as the Ranger series and the Surveyor series. Small production runs made it possible to realize savings by photographing a prototype to produce documentation of cabling runs, plumbing runs, temperature control blankets, paint patterns, etc. Photo assembly drawings were prepared by mounting the negatives of photographs in the drawing format and the appropriate callouts were applied in the normal manner. Shown is a Ranger cable installation. This type of drawing is also used extensively on our deep space net to record changes made to electronic assemblies.

Gimbal Actuator Assembly

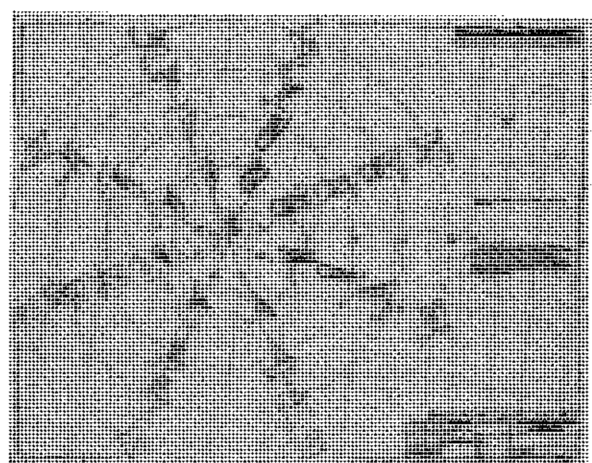


Another type of convience drawing, that I'm sure is familiar to most Engineering Graphics teachers, is the exploded pictorial drawing. These drawings of a Gimbal Actuator Assembly use this technique as well as a gear train schematic and a wiring diagram.



Sample Drawing Computer Rotation

A few years ago we acquired our first pieces of computer aided design equipment; by today's standards, these were quite primative, but a start. In order to demonstrate our capability, this drawing of a rocket motor fitting assembly was prepared. Many times



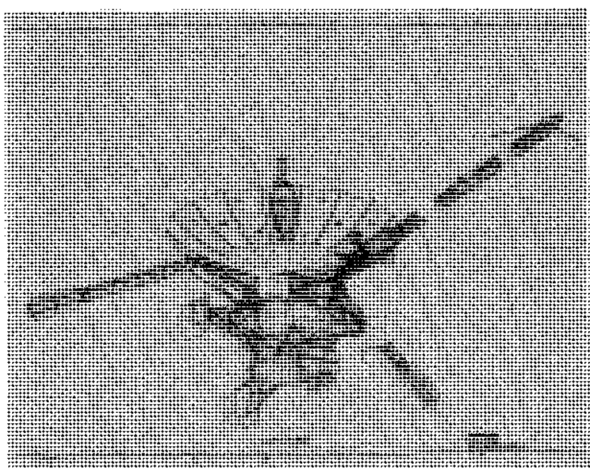
during the machining of a part, the shop needs a view not provided on the drawing. These added views frequently require several days of descriptive geometry development to provide the required information.

When the basic information describing a part has been digitized on the computer, additional views can be provided within minutes.

In space we have no left or right, up or down to use for reference, even on three axis stabalized spacecraft. So, a navigation system of clock and cone have been devised. In order to do this the spacecraft is oriented on a Sun/Earth/Reference Star system. So, the Sun/Earth axis is the cone system, sun orientation is 0° cone, Earth orientation is 180° cone. The Reference Star is 0° clock and rotating in a clockwise direction, while looking in the earth direction, defines advancing clock positions.

The fitting shown in the center of the figure is therefore the top view; the eight identical figures on the outside are merely rotated 45° in clock, 180° in cone, and show the bottom view of the fitting.

III. GRAPHIC COMMUNICATION FOR PROMOTION



Galileo 84 Baseline Pictorial

Pictorial Drawings, i.e., isometric, trimetric, etc., are prepared during the development of a spacecraft. This type of drawing is really a "sales" drawing as it assists a person making a presentation, be it to company officers or others, all the way up through NASA Headquarters and Congress, by showing the proposed product in three dimensions for easy visualization.

Pictorial Drawings can also be used in reports, manuals, specifications, etc. -- even on the covers of engineering text books.

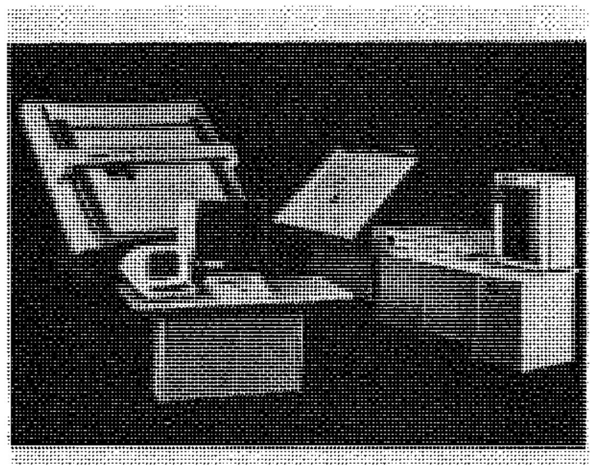
IV. GRAPHIC COMMUNICATIONS OF THE FUTURE

Up to this point, this paper has been devoted to the traditional methods of developing graphic communications, with a few "gimmicks" to improve efficiency or provide an expedience in the interest of time. We must, however, address the future.

The design section has been involved in computer aided design for several years as was illustrated by a previous section of this paper. But, this year, a significant improvement has been made by the acquisition and installation of a Computervision Designer System. Our new equipment provides for three design stations and more are being planned for the future.

Although I am not a computer expert, I would like to describe our new equipment. Any questions which you may have may be addressed to me (see complete address at the end of this paper) and I will forward them to the appropriate people on our staff for reply.

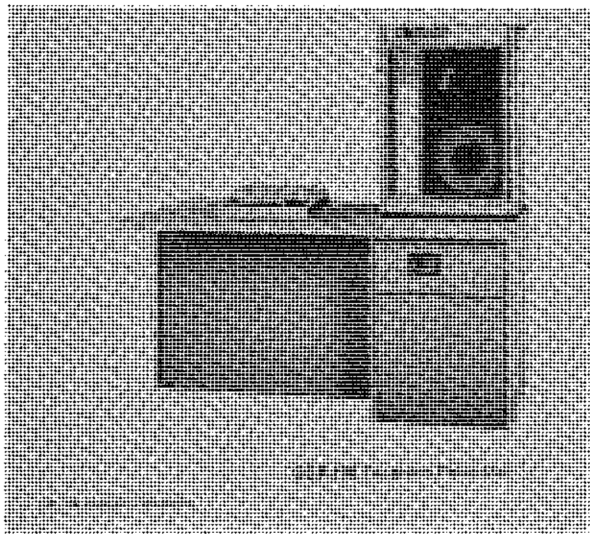
DESIGNER SYSTEM



The heart of the graphics system is called CADDS - Computer Aided Design and Drafting System. This is a multi-application software system for mechanical, electrical, piping, wire diagrams, etc. Also, a programming language is included in the CADDS package. This processor, called PEP (Parametric Element Processor) allows the creation and editing of engineering design data, in a parametric sense.

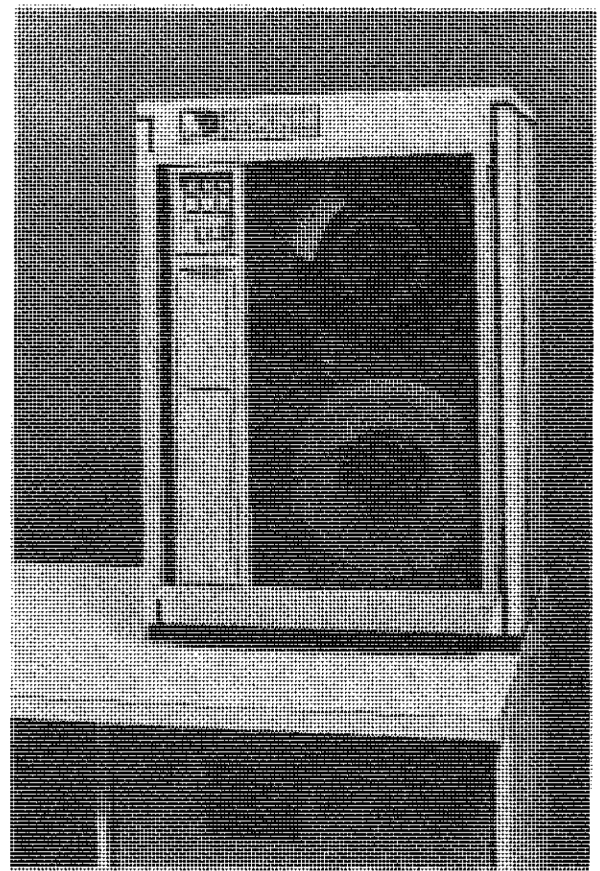
The use of the Graphics equipment is English orented and does not require the knowledge of software and/or programming. This package is designed for a draftsman or design engineer to generate layouts and production drawings in engineering designs.

As presently set up in our section, a design station consists of the following equipment: a design console, a tele-display, and a design pen and tablet.



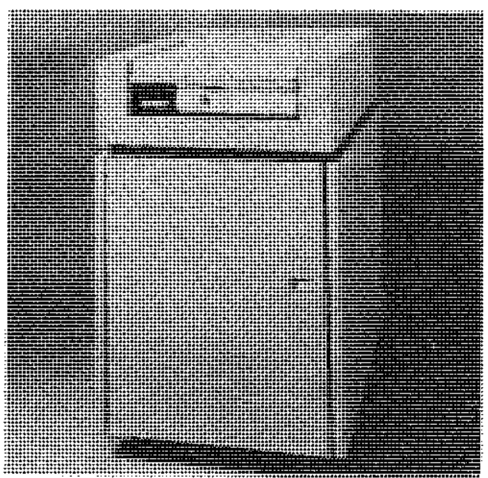
COMPUTER

The computer is the workhorse of the graphics system. All interface and software number crunching is done on the central processing unit (CPU). The CPU is a 16-bit mini computer capable of handling multiple interactive users and background tasks.



MAGNETIC TAPE STORAGE UNIT

The mag tape is the basic input/output (I/O) device in a graphics system. All software is loaded via the mag tape. Parts, designs, or any data, created on the graphics system are stored on the mag tape for archival storage.

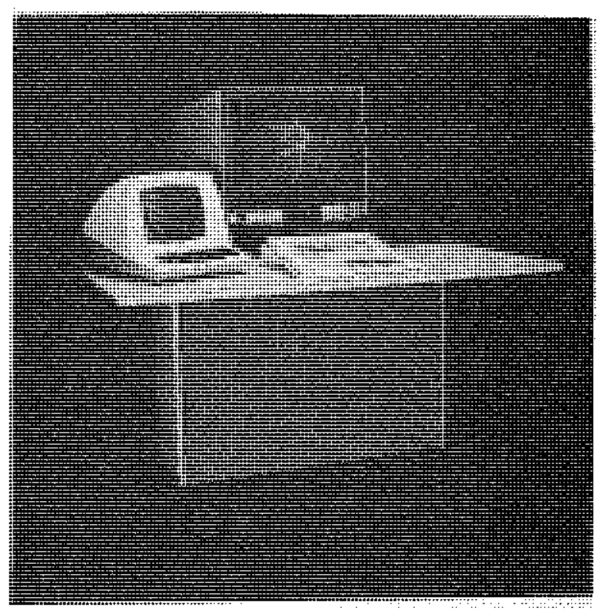


DISC STORAGE UNIT

The disc storage unit is used as the resident storage place for all software and data created by the system. Because of the quick access capability of the high speed disc, this unit lends itself well for an on-line storage for the graphics system. Multiple discs can be used for more space.

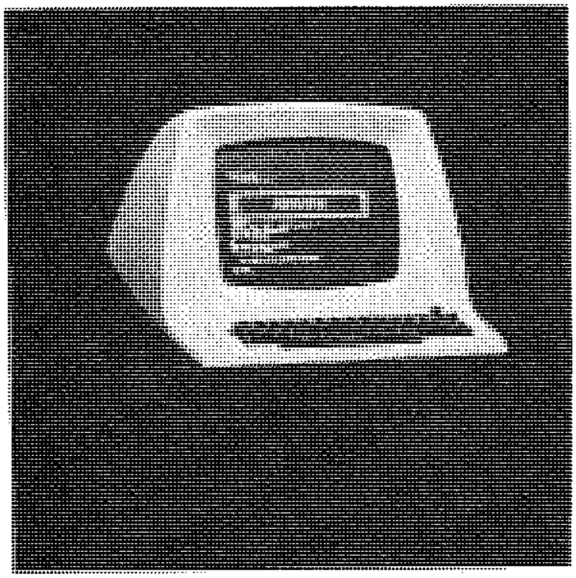
Current Storage Capacity: 80 million bytes (Characters).

Future Plan: 300 million bytes.



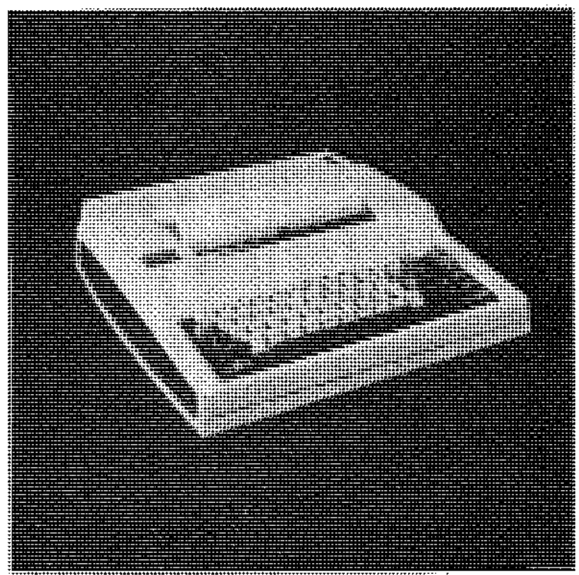
DESIGN CONSOLE

The design console features a 19 inch (diagonal) CRT and a work station to provide space for the ancilliary equipment.



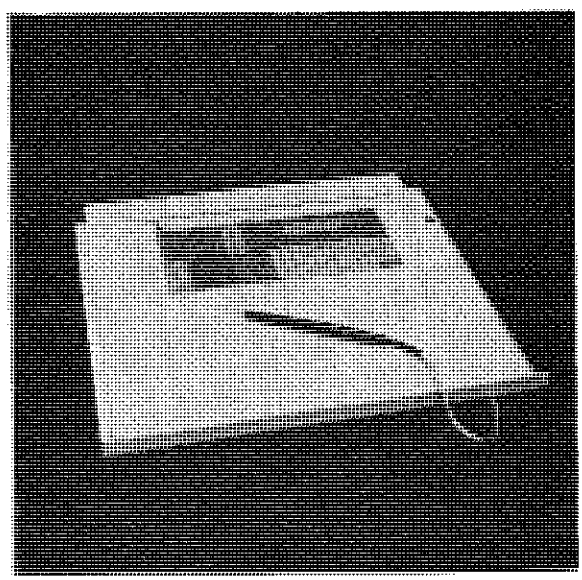
THE CRT DESIGN STATION

The CRT design station is an interactive design station that allows the user to see his graphic data on a CRT screen. This allows creation and editing capability on designs that can be seen on the screen. The user can see 2-D and 3-D data in multiple views to aid him in designing his parts. The most popular function of the CRT station is design and editing.



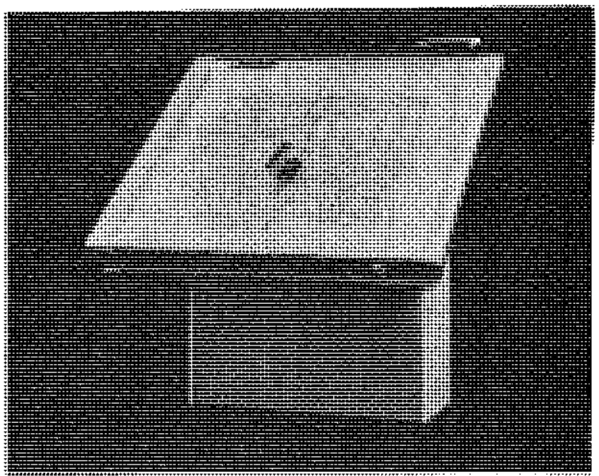
TELEWRITER

The telewriter is used to enter ommands, text and display general information, system prompts and error messages, and provides an permanent record of communication with the system.



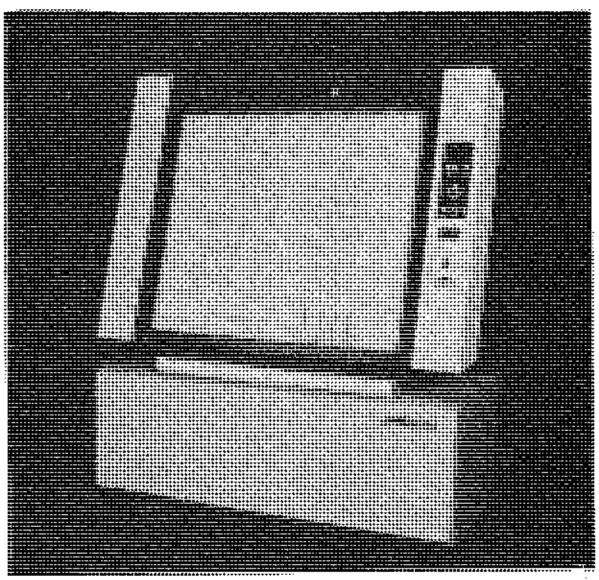
STAND-ALONE DIGITIZER

The stand-alone digitizer is designed to input already existing drawings to the graphics system. The user can digitize the data and then send the completed work to a background plotter.



DIGITIZER/PLOTTER

The digitizer plotter (JPL does not have one) combines the input digitizing with output plotting on one station. As the user digitizes the data, an instant plotback capability is available to eliminate blind digitizing. Four-pen capability allows multi-color with ball point, felt, or wet ink type pens.



HIGH-SPEED PLOTTERS

High-speed plotters are output devices that allow the user to get hard copies of databases. These devices should be run in background, which relieves the sending terminal for other interactive tasks.

PEN PLOTTERS

Stand-alone pen plotters can be used to generate ink plots on paper. The user can use vellum or Mylar™ papers. The ink can be ballpoint, felt, or wet ink. The advantage of this type plotter is the accuracy and quality with reasonable speed.

Maximum axial speed: 30 in/second
Resolution: 0.0005 in.

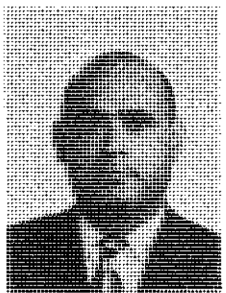
SIMULTANEOUS 2D/3D DATABASE

Part of the software provided with the Graphics system at JPL, the simultaneous 2D/3D database gives true 3-D capability -- not just a "wire-cage" drawing as a pictorial. The geometry presented is a true model, not just a representation, and both 2-D and 3-D software can be used simultaneously, which eliminates the necessity for disc "switching".

IF I CAN BE OF ANY ASSISTANCE SUCH AS COPIES OF DRAWINGS, SHOWN AS SLIDES OR OTHER PROBLEM ILLUSTRATIONS, PLEASE WRITE STATING YOUR DESIRES, AND I WILL BE HAPPY TO SEND WHAT I CAN.

HERBERT H. GERNANDT 171-301
JET PROPULSION LABORATORY
4800 OAK GROVE DRIVE
PASADENA, CA 91109

USING THE COMPUTER TO PLOT THE CENTER OF GRAVITY OF PLANE AREAS



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DEPARTMENT OF MATHEMATICS
HAIFA, ISRAEL

The Center of Gravity of the plane areas of practically all commonly used geometrical figures, such as triangles, rectangles, trapezoids, segments of circles, etc . . ., are easy to locate.

However, in order to find the location of the C.O.G. of a polygon, the usual method consists of dividing the polygon into a certain number of elementary areas, the C.O.G. of which would be known, and, by assuming each component area to represent a force, to find the resultant force and its point of application, by using the equation of moments.

Obviously this tedious job could be given to the computer which could be programmed to produce the drawing of the polygon considered, plot the C.O.G. point of application and determine its coordinates very accurately and certainly very quickly.

On the other hand, if the plane area is bounded by a curved line or a combination of curved and straight lines, it is practically impossible to obtain a graphical solution and here again the computer could prove of great value.

C.O.G. OF A POLYGON:

As suggested, the computer could be programmed to plot the C.O.G. of the area of any polygon, concave or convex, and of any number of sides. The procedure consists in dividing the area covered by the polygon and the X-axis into a number of trapezoids, the areas of which could be represented by forces, positive or negative, as shown in Fig. 1.

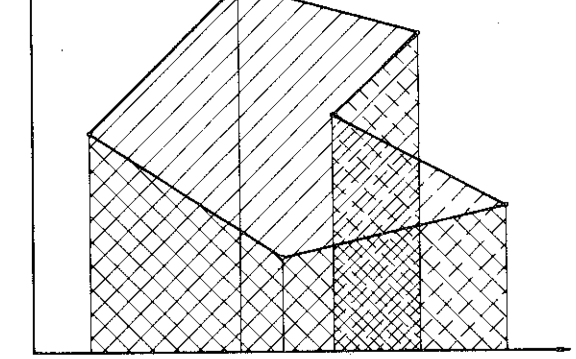


fig. 1 DIVISION INTO TRAPEZOIDS

The next step is to have the computer calculate the various moments, and thus determine the resultant area-force and the C.O.G. point of application, by using the equation:

CA * COG = SUM OF (EA * EC)

in which

CA = cumulative polygon area

COG = Polygon C.O.G. Coordinate

EA = component trapezoid area with respective positive or negative sign

EC = component trapezoid C.O.G. coordinate

C.O.G. COMPUTER PROGRAM FOR A POLYGON:

Using FORTRAN as a computer language, the location of the C.O.G. could be programmed as a subroutine, the pertinent part of which would read as follows:

```
     ---------------
     ---------------
     EMIX = 0.      ------ moments of com-
     EMIY = 0.             ponent trapezoids
     STØT = 0.      ------ polygon area
     DØ 10 I=1,N ------ starting a loop
                           for N-sided polygon
     M = I+1
     IF(I.EQ.N)M=1
     BASE = X(M)-X(I)
     YMID = 0.5 * (Y(I)+Y(M))
     SI = BASE * YMID --trapezoid area
     FACT = Y(I)+2.*Y(M) --- a factor
     XGI = X(I)+BASE*FACT/(6.*YMID)
     YGI = 0.5*Y(I)+FACT*(Y(M)-Y(I))/(12.*YMID)
                    ------ XGI,YGI = trapezoid
                           C.O.G. coordinates
     EMIX = EMIX+SI*XGI
     EMIY = EMIY+SI*YGI
     STØT = STØT+SI
                    ------ cumulative area
     --------------
     --------------
10   CØNTINUE
     XGR = EMIX/STØT  -------- polygon C.O.G.
     YGR = EMIY/STØT           coordinates
     ---------------
     ---------------
```

Further requirements could be introduced in the subroutine to provide for the plotting of the polygon, the axis, the C.O.G. location and the printing of its coordinates.

A typical computer plotter output is shown in Fig. 2.

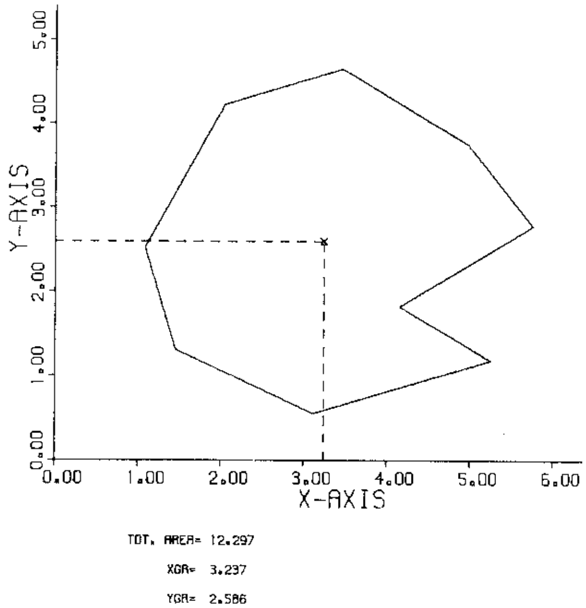


fig. 2 POLYGON COMPUTER OUTPUT

PLOTTING A CURVE:

In order to consider the shape of any area, that is, an area bounded partly or wholly by a curved line passing through a number of given points, it is necessary -- unless the curve could be represented by a known function -- to start by plotting that curve.

It is suggested that the Lagrange Interpolation Polynome be used and a subroutine programmed, based on the following equation:

YC(I) = SUM OF (Y(K)*PR)

In which:

PR = PRODUCT OF (XC(I)-X(L))/(X(K)-X(L))

for L ≠ K

assuming:

I = J .. to .. M, a large number of points through which the curve passes, starting a point number J and ending at point number M

K = 1 .. to .. N the limited number of given points through which the

L = 1 .. to .. N curve is to pass

X(K) or X(L) are given

XC(I),YC(I) are the curve points coordinates

The main part of such a sub-program would read as follows:

```
SUBRØUTINE CURVE  (X,Y,N,J,M,XC,YC)

        ----------X,Y=given points co-
                     ordinates

        ----------  N=number of given
                      points

        ----------  J=given starting
                      point number

        ----------  M=end point number

        --------XC,YC=curve points
                      coordinates

 DIMENSION X(10),Y(10),XC(100),YC(100)

 M=J+10(N-1) -----  10 (or more) curve
                    points between pair
                    of given points

 DX=(X(N)-X(1))/(M-J)
       ----------  increments

 DØ 30 I=J,M

 ---------------

 ---------------

 XC(I) = XCP+DX
       -----------  XCP=preceding XC(I)

 YC(I) = 0.

 DØ 20 K = 1,N

 PR = 1.

 DØ 10 L = 1,N

 IF(K.EQ.L)GØ TØ 10

 PR = PR*(XC(I)-X(L))/(X(K)-X(L))

10  CØNTINUE

 YC(I) = YC(I)+PR*Y(K)

20  CØNTINUE

 CALL PLØT (XC(I),YC(I),2)

 ------------

 ------------

 ------------

30  CØNTINUE

 ------------

 ------------
```

Such a program would enable us to establish and store the values of the component coordinate points of the curve: XC,YC.

Now, if we consider that curve as a broken line made out of a great number of component sides, me may establish as many trapezoids made out of these sides and the increments DX along the X-axis, as shown in Fig. 3.

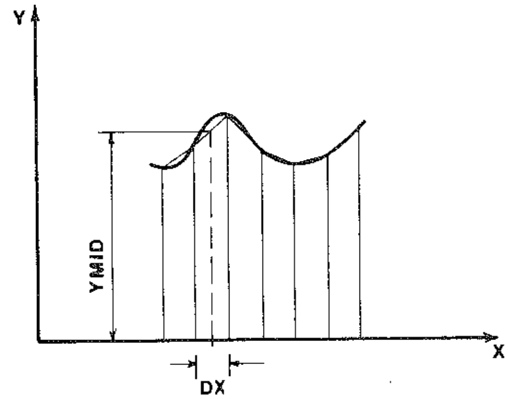


fig. 3 CURVE DIVISION INTO TRAPEZOIDS

If the curve could be represented by a function, it would be plotted through a series of points obtained from such a function, which obviously could have the same role as the XC, YC coordinates previously mentioned.

C.O.G. OF A PLANE AREA:

If we consider any plane area, bounded by curved and straight lines, concave or convex, it is possible again to divide the area covered by the given figure and the X-axis, into a number of trapezoids, the areas of which could be represented by forces, positive or negative, as shown in fig. 4.

Having considered the given area as a polygon, the curved component parts made out of a very large number of sides, we may use now the subroutine establishing the C.O.G. of a polygon; the points entered in this subroutine would be the XC,YC coordinates stored for

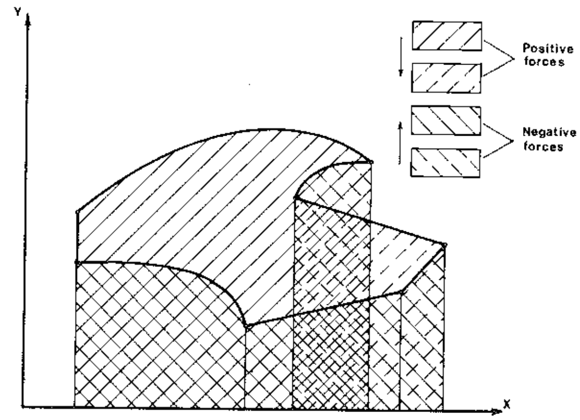


fig. 4 TRAPEZOIDS IN IRREGULAR AREA

the various curved lines, complemented by the coordinates of the straight line parts.

Thus, such a subroutine could be formed as follows:

SUBROUTINE ANAREA (X,Y,N,STØT,XGR,YGR)

----------- in which:

X,Y = XC,YC, . . .

N = number of polygon vertices

STØT = cumulative area

XGR, YGR } = C.O.G. coordinates

Fig. 5 shows a plotter output for such an area, made out of curves passing through the points indicated, as well as straight lines.

TOT. AREA is the area in square inches for the scale considered, XGR and YGR are the coordinates, in inches, of the C.O.G.

<u>C.O.G. OF SOLIDS:</u>

Althought the subject of this paper deals with the location of the C.O.G. of a plane area, it is possible to see how the method could be extended to the location of the C.O.G. in solids.

The procedure would consist in dividing the solid considered into elementary sections, each represented by forces, F1, F2, ... The magnitude of these forces and their points of application could be calculated from the ANAREA subroutine previously discussed.

F1,F2 . . . would be, in turn, introduced in a program (or sub-program) that would:

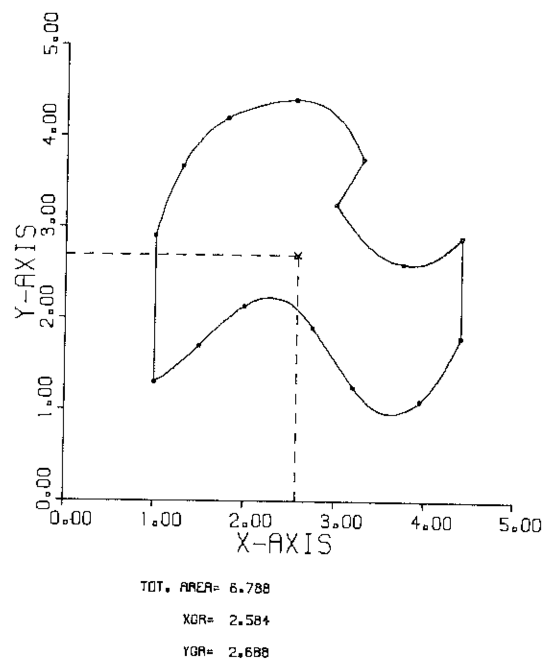


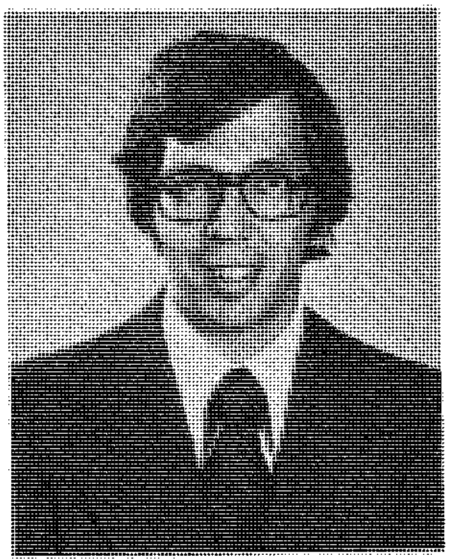
fig. 5 IRREGULAR AREA COMPUTER OUTPUT

a) Integrate the various section force-areas to form the cumulative volume and subsequently the weight of the solid considered.

b) Determine the location of the point of application of the resultant-force F, to the section forces F1,F2. . . .

Thus, the weight and the C.O.G. of the solid considered could be determined accurately and very rapidly.

COMPUTER AIDED INSTRUCTION USING STUDENT INTERACTIVE VISUALS



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MILWAUKEE, WI

INTRODUCTION

Very often instructors of freshman engineering graphics emply various multi-media or audiovisual methods in an attempt to enhance the motivation of students. The market place has been filled with a great number of films, videotapes, slides, film strips, overhead transparencies, realia, computer graphics, computer assisted instruction, etc., to assist these instructors. Of these many methods, computer graphics is relatively new to many school curricula, and, is growing in usage each year. In general, freshmen who are taking a first course in computer programming, fortran, basic etc., are infatuated with the novelty of using the computer - it's fun. Computer graphics, then, can be one way of capturing students' interest or infatuation with the computer and focusing it on engineering graphics. Too much or too little motivation can hinder learning. However, not many teachers would reject the notion that motivated students are easier to teach and in many cases learn more. Computer graphics can also be of assistance in another area of engineering graphics, that of assisting the instructor with individualized attention. This can be accomplished by construction of interactive programs and specialized packages to assist students with individual concepts, acting as a tutorial. What is then created is computer assisted instruction, with visual enhancement.

BACKGROUND

One of the objectives of a local course improvement project at Marquette University is to develop computer graphics software for implementation into the curriculum. This paper describes one such software package, how it interacts with students, its potential value to a system, student acceptance and possible applications. The graphics package, currently labeled "GRAPHIC I", was written by a graduate student and uses the Terminal Control System (TCS) package with the Tektronix "Plot-10" system software. The program is very interactive and uses both keyboard and cursor control. The college Computer Aided Design and Graphics Laboratory also currently uses Tektronix terminals. GRAPHIC I is presently an orthographic projection or multiview self learning package utilizing computer graphics.

GRAPHIC I allows the student to draw or view solutions (or both) to various orthographic projection problems. The student may either construct the orthographic views from a given pictorial image or construct the pictorial from the given principal multiviews (Fig. 1). While this package can assist a student in enhancing his/her ability to visualize, the author is not convinced that computer graphics will teach visualization, and, is in no way intended to be a replacement for appropriate classroom and lab instruction.

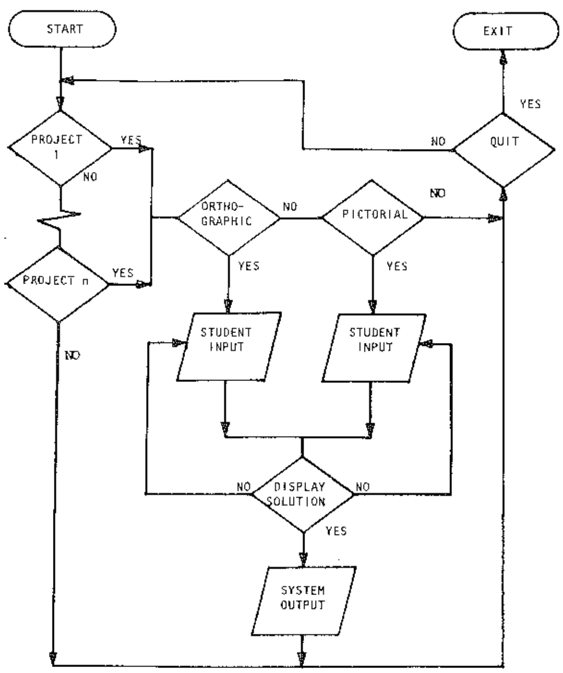

FIGURE 1

In actual operation, GRAPHIC I follows the visual thinking model expressed by McKim[1] (Fig. 2). In the context of using the tutorial package, each of the three concepts, seeing, imagining, drawing and their overlappings are used. Where seeing overlaps imagining, seeing the "given" image in the problem gives motivation to imagination and the subsequent formation of a mental image. Where imagining overlaps drawing, the mental image becomes the raw material for the expression of the object through a visual medium, in our case the CRT screen. Where drawing and seeing overlap, seeing the "given" image facilitates drawing and also gives visual feedback and reinforcement to the student.

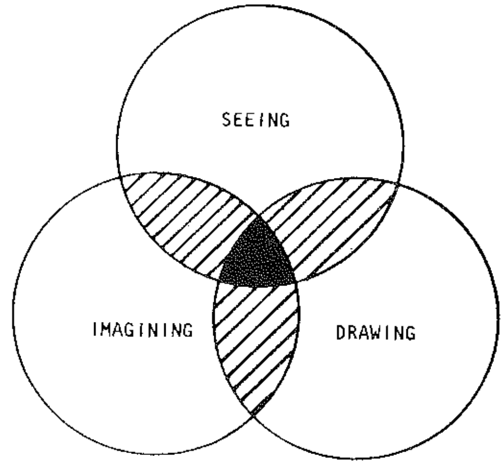

FIGURE 2

KEY OPERATIONS:

A - DISPLAY SOLUTION
D - DRAW A LINE
E - ERASE SCREEN
M - MOVE CURSOR
Q - QUIT SESSION
H - DRAW A DASHED LINE

PROJECTS CURRENTLY AVAILABLE :
----

1. SIMPLE CUBE
2. CUT CORNER CUBE
3. STEPPED CUBE
4. WEDGE
5. CUT WEDGE

INPUT PROJECT NUMBER OR Q FOR QUIT ...

FIGURE 3

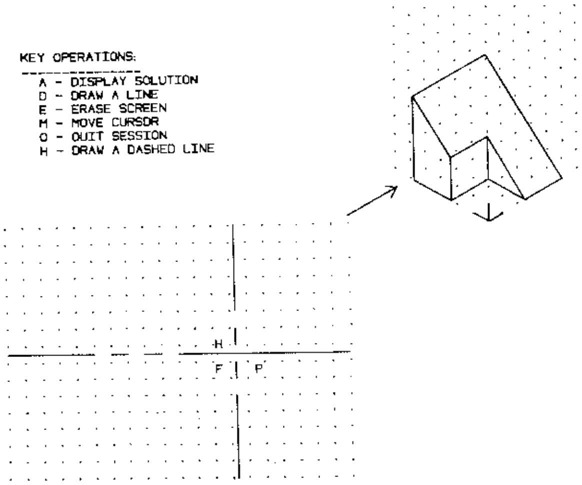

FIGURE 4

INTERACTION WITH THE PROGRAM

The student enters the program and views the key operation list and the projects currently available (Fig. 3). After making a choice the program promts: "Would you like to practice orthographic or pictorial drawing?" (O/P). If the student chooses "orthographic", the program replies by drawing a pictorial view of the problem, a direction of sight arrow, the three principal planes of projection, a dot matrix for scaling and reprints the key operation list (Fig. 4).

At this point the interactive cursor is activated, and, using the key operations the student may draw the three orthographic views in their appropriate positions. If noticeable errors are made, the student may erase the screen and begin again. When he/she has completed the problem, the solution can be either overlayed or viewed on a clean screen. This feedback allows the student to know immediately whether he/she is correct or in error.

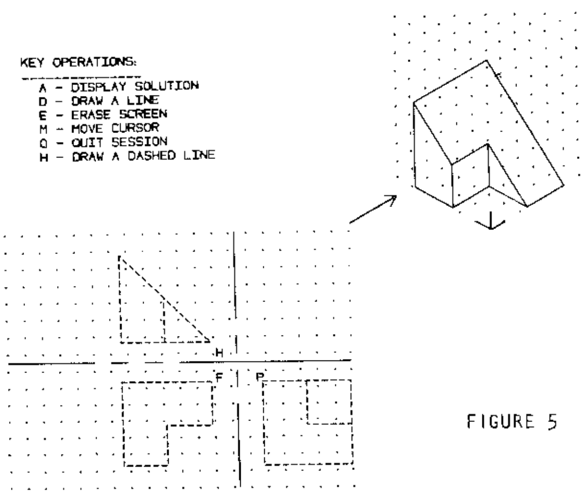

FIGURE 5

Figure 5 shows an example of an incorrect student solution, dashed lines have been used for illustrative purposes only. Figure 6 shows the correct solution overlayed onto the incorrect solution. At this time the student may continue the tutorial by selecting another problem, or quit. If a hard copy device is available the student may copy his/her solution, erase the screen, call the correct solution, copy that solution and compare the two. This also provides the student with a record of his progress.

Students presently have access to the graphics terminals on an "as needed" basis only. When a student is identified as needing assistance, he/she may may choose the option of the computer graphics tutorial. An alternative option is to seek assistance from one of several teaching assistants or the course instructors. It is felt that giving students this additional path or course of action will act as an increasing motivational

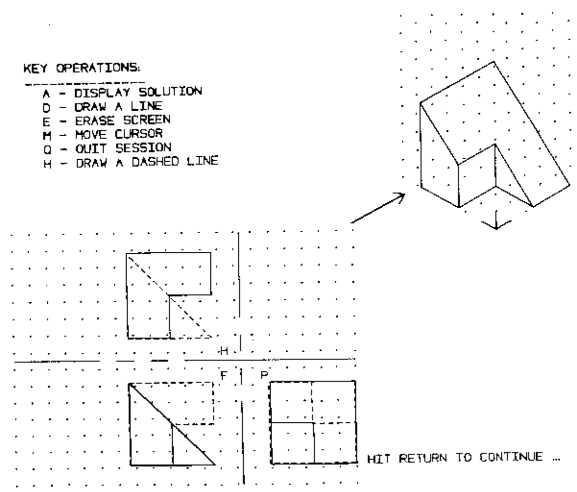

FIGURE 6

device. A device that both attracts on the basis of novelty and utility.

STUDENT ACCEPTANCE

A number of students (40) were surveyed regarding this reaction to using GRAPHIC I. Of the thirty-five students in the sample, 82% had not encountered any previous experience in graphics, and, all forty experienced computer aided instruction in addition to the basic use of the graphics terminal. Pairs of students used the terminal for approximately 30-40 minutes. When they had finished using the tutorial they were asked to complete a questionnaire.

At the conclusion of the sample experiences, all of the students indicated that they required very little assistance before using the tutorial. Eighty-five percent (34) of the students stated that the tutorial would help them significantly in a self directed learning situation in graphics. All forty students also indicated that they would enjoy this type of instruction.

Although the sample and survey were unscientific in nature, the feedback provided was positive. Based (in part) on the above responses, it was decided to pursue development of this area. The following paragraphs are additional conclusions.

CONCLUSIONS

Advantages. The graphics package described is one way of using computer interactive graphics to assist an instructor in giving individualized attention. While an instructor is not usually present during the use of the package, students can be positively affected if only in viewing various correct solutions to reinforce the projection theory. Most students require little or no assistance.

Students can interact with GRAPHIC I after a very brief orientation. There is no need for knowledge of computer programming. Certainly there is value in programming, entering of coordinate values, connecting spatial points, etc., however, it is not felt that students should be burdened with this while learning these basic concepts.

The problems used in the tutorial can be alternated or used in a logical progression from simple to complex, i.e., a group of low complexity problems can be used during a given time period, then can be replaced by intermediate problems, then higher complexity, etc. The package can be used by pairs of students, but, more than three at one time is discouraged. The general mode of operation can be applied to other concepts as well.

If a hard copy device is available the visuals produced with this package will make excellent masters for overhead transparencies to be used in a classroom setting.

Disadvantages. Presently the package does not have the capability of dealing with arcs and circles, in an interactive fashion. Therefore, problems are limited to straight line work.

The tutorial requires the use interactive controls in the use of a Crosshair Cursor and is not usable on all graphic terminals.

Lack of an adequate number of student terminals. Understandably, this is a problem in many schools. Present facilities will not allow for a dedicated computer graphics/instructional laboratory for students. However, it is anticipated that this will change as progress is made in this area. Technology exists to bring computer graphics into the classroom via other mediums, i.e., video, film, etc. and may represent viable alternatives under certain conditions.

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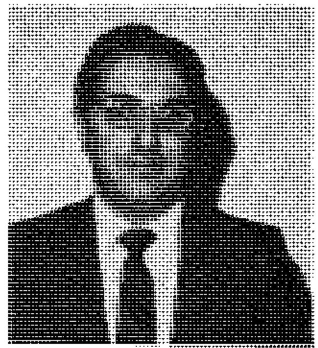
COMPUTER GRAPHICS - "PERPLEXING" AND "TROUBLESOME" QUESTIONS



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In the Winter 1979 issue of the Engineering Design Graphics Journal, an article by Roubert McDougal (University of Nebraska) described the use of computer graphics by members of the engineering graphics community. (1) (Ed.Note: See also, the follow-up article by McDougal this issue.) Within the pages of that article Paul DeJong commented on the article and further stated what he considered to be perplexing and troublesome questions in the implementation of computer graphics courses. These questions and thoughts have also been expressed many times in many ways by many other faculty members. This article is a review of these questions to give those who are concerned with these issues some ideas as to how these particular problems might be resolved. His questions were:

First, exactly what does computer graphics teach or provide to the student that good sketching techniques do not?

Second, will the student be able to use that specialized ability after graduation?

Third, what subject material is removed from the curriculum to provide time for computer graphics?

Fourth, where does the money come from to obtain the equipment to provide "extensive hands-on" experience for one thousand freshmen?

FIRST - The initial question is really more than just asking whether the computer as a tool could be substituted for the pencil. The question is sort of like saying that since we have cars, there is no need to learn to walk. This is, of course, over-reacting to the question, but at the same time one must also recognize that sketching and drafting techniques are not as high on the priority listing pf objectives for the current Engineering Graphics courses as they once were. Although question three is somewhat being answered here (what items will be removed from the course) and that is the so called "good sketching techniques". (2) This does not, of course, remove sketching and/or drafting from the course, but does limit the emphasis placed on these areas considering the fact that few engineering graduates today are initiated into the engineering field by working as draftsmen for a period of time as was once the rule.

The primary item that the computer does that a pencil does not, is to motivate the student. (3) The instructor may motivate the student in the teaching of multi-views utilizing pencil techniques, but with the same instructional motivation, the teacher is further assisted by the motivation that inherently comes from the use of the computer. In addition, the non-graphics faculty and those in industry are impressed and expects our students to have some computer graphics experiences.

At this point, one could question the expense and excessive time involved in the use of the computer. These could be valid criticisms if one were to uncreatively "dump" a computer graphics unit into an existing course or develop a new course for the sole purpose of teaching computer graphics. (4) This will be further discussed in the sections headed third and fourth.

SECOND - The question as to whether any material taught in a graphics course will be utilized after graduation seems to always have been a special can of worms for the graphics teacher. Although it is admirable that the graphics teachers who primarily teach freshmen are concerned with what the student will be using four or so years from the current classroom, this is really not a realistic nor a pragmatic outlook. Neither students nor industry are really in a position to aid the graphics instructor in their search for meaningful course content. The people the graphics instructor must convience that the course content is of value is the faculty right on their campus. After all, they have the authority to either vote graphics in or out when the going gets tough. It is they who must be convienced that this "specialized ability" is really of value.

Actually, this so-called "specialized computer ability" is not specialized at all. In fact, no matter what the student is taught in the computer graphics area the material will more than likely not match anything that will be used either in industry or on your campút without some adjustments. At the same time, any or all of the experiences the students have with computer graphics will be adaptable to some other computer set-up. That is, no matter what you teach can never be used exactly, yet everything you teach will be of some value one way or another. Contradictory? Well not at all, as this is true of all work that students experience with the computer. The next language or system they run into will invariably become easier for them to use whether it be the following term on campus or the following years somewhere in industry.

THIRD - Many institutions do just what this third question asks and that is they remove items from the traditional graphics courses to insert a unit in computer graphics. If this is what the institution wants, that is, to remove some of the basic graphics from the curriculum, then by all means a computer graphics unit would be a useful replacement. However, if this is not the intention, then there is no reason why it has to be done. Although the computer is an awfully expensive supplement for the pencil, it can be used as a motivational tool within the graphics material. Simple programs can be developed utilizing graphs and equations or other forms of charts depending upon what is already in the course. (2) Actually, this might be more difficult than implementing a three-dimensional graphics program which would motivate the students in the spatial visualization techniques of orthographic projection at its basic level or in the descriptive geometric approach. (3) Using computer graphics to support the already existing graphics material means that very little need be removed from the course or curriculum other than the emphasis on the techniques of sketching, lettering, drafting, geometric construction, etc. What (?), these topics are already cut to the bone?! Well, take another look or you might find the bone missing. Graphics may be coming back to some degree, but don't let your guard down for one moment, as you might find graphics missing again.(5).

FOURTH - There is no question that the purchasing of computer equipment is expensive. However, it is becoming cheaper all the time and stand alone systems are making their entrance into the engineering graphics areas with software already available. (6) In fact, many of these systems are being purchased by industry and are being used more and more by industry. (7) One of these methods used to get money for the equipment is by a method that all the rest of the University community has done but the graphics people have been reluctant to do so, and that is by writing proposals and obtaining grants. The Computer Graphics Committee of the Graphics Division attempted to develop a subcommittee which would look into this well of fortune, but graphics people being what they are did not find this area particularly stimulating and therefore this committee is still somewhat in limbo. However, there is still another approach which doesn't usually cost a dime. That is, there must be some sort of a computer on campus which is available for general usage. Unfortunately, this takes a little politicing and maybe some creativity to figure out how to get the computer people to embrace you and graphics. (3) Primarily their entire lives resolve about alphanumeric characters and graphics is not always their favorite subject. There is nothing wrong however with asking them to work with you on some graphical outputs that come in the form of characters on their printout paper. This can be the first step and if they somehow do have a plotter available there might even be someone within your computer facility that might be looking for a friend on the outside to give them moral support in this graphical world of ours. If there is no plotter available, a nice touch is to apply for a grant or twist your department head's or dean's arm (who ever has more bucks and a soft spot for graphics) and give the plotter to the people at your computer facility as a gift. They may look at this as a trojan horse, and actually, that is exactly what it is.

The previous paragraph was speaking merely to the "foot in the door" element of getting the money to start a computer graphics system, but question four also stated "extensive hands on experience for one thousand freshmen". Well, 600 students per year are being handled at the University of Illinois Chicago Circle Campus as described in a previous article written by this writer. (4) The "extensive hands on" is defined as the students using either card punch machines or terminals, then there is no problem. However, to actually have a number of this nature get close enough to the computer itself to even see it would be unrealistic in this writer's opinion.

There are some who have received grants for the purpose of developing stand alone systems for a large number of freshmen in a core curriculum. However, when one pins these people down as to the actual numbers, the numbers of hours in a day, and the amount of equipment that would be needed, the realism quickly disappears. In any case, why would an institution wish to have direct hands on experience for all of their students when in essence only a limited number of people need to have hands on the computer equipment. That is, specialists in computer hardware and software may be directly involved with the computer itself but the majority of engineers interact with the computer by some interfaced piece of equipment such as a terminal or a card punch machine. The smaller numbers of students and especially when the student's specialty is known.

Conclusion

There is no one correct set of answers to these questions. What might be good for one institution may not work for another. One thing is for sure and that is that faculty attitude is extremely important in whether or not an institution successfully provides its students with a meaningful computer graphics experience. The lack of computer expertise and money did not stop this "old timer" from implementing computer graphics as early as 1972, and to this day it has not directly cost the department one dime for computer hardware or software. "Where there is a will there is a way". If you have the "will" maybe we can talk about it to find "the way" for you.

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from the midyear conference

LEST WE FORGET THE GOALS. . . .

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I don't want to belabor the obvious, but you may have noticed that since the Grinter report, a general revolution has taken place within what was then a rather stable Engineering curriculum; one in which we had a strong if not overriding voice which now seems at times to either fall on deaf ears or be a voice in the wilderness.

Even more far-reaching has been the effect of technological advances since that august report - particularly in solid state phenomena - but also in energy utilization and even basic attitudes. The effect of both these forces has been that we feel as if we have - and in actuality have - been forced to give up time, lots of time in fact, to broaden our students' education to include more humanities, sciences, and it seems lots of computer-oriented courses. Ever heard of cone-locus lately?

There is something inevitable about all this and you should know if you don't already that we are not alone. All the degree granting curricula have had to give up time to produce room for these new technologies and humanities. The result may have been that the student is the one who pays. I recall rather clearly getting credit for studying basic fluid flow at least three times - once in Mechanics, once in Heat Transfer and once in Thermodynamics. I thought that it was quite considerate at the time but I doubt that we are quite so generous today. In most of the courses I have been associated with recently, we have by design or by accident considered "once is enough". The end result of this pressure of encroachment on our teaching time has certainly, we would agree, reduced our courses to a mere shadow of their former selves and left us pretty defensive and some might even say paranoid. However, we should observe that just because you are paranoid, it doesn't mean that they aren't out to get you.

THE SEARCH FOR "RESPECTABILITY"

We have tried many different things in what some might consider a futile effort to re-establish or "save" graphics, since a lot of people seem quite willing and eager to bury us.

Ever since they took away our T-squares, we tend to cry in our beer and mutter to ourselves somewhat. We think the Ag Engineers are mad at us because we aren't using instruments and the Computer engineers seem to be mad at us no matter what. Naturally, neither is mad at us at all, (we hope), but are watchful and expecting the time we use to be productive in their view, a view which varies widely between curricula and institutions. The consequence is that we tend to exhibit masochistic tendencies.

Our first efforts may have been "closed circuit television". This seemed to provide a vehicle to deliver outstanding lectures using excellent educational aides and over-the-shoulder teaching. Unfortunately, many of our students are accustomed to television and at an intellectual level of "Love Boat" with the visual characteristics of "It's a Living" and tend to mentally "shut down" during television lectures. We also found, a little to our dismay, that television provided a means by which we could replace ourselves.

The next attempt was probably design which, I believe, we would all agree is one of the most powerful and useful courses in a student's academic career if they stop to remember where they learned all that good stuff. Many of us have testimonials to that effect. It is unfortunate that too many individuals in the degree granting departments labor under the illusion only they have been "bestowed" with the knowledge to teach design or fail to see how design can be accomplished without abundant decimal points.

More recently it has been Descriptive Geometry as such that would be our salvation, and I have heard rumblings aboult Geometric Tolerancing, but probably it is Computer Graphics that is in the Messiah's role. I should quickly add that I'm a subscriber to these things myself and have made several CCTV tapes, enjoy the mental challenge of Descriptive Geometry and Geometric Tolerancing, the fun of a touch Design problem or Computer program. Like many families, we have a 16K Pet in our basement with which I frequently wrestle with until 2 A.M. It usually wins because I often fail to define my arrays.

But I wonder sometimes if we realize that most of these things are tools to an Engineer; Computer Graphics particularly, since it is the electronic equivalent of a drafting machine. Worse yet, the current demands of education - rightly or wrongly - are knowledge of principles, not these manual skills. Most companies cannot afford to use expensive engineering talent at the drawing board, except in the most minimal way.

WHY DO WE DO THIS?

Initially, computers were genuinely cumbersome and inaccessible so presented no threat to a well planned graphics course. However, the new generations of computers are relatively cheap, flexible, and agile, so to speak. Many of us would and are turning to convert our courses from "pencil" graphics to "computer" graphics because this seems timely, current, and has the blessings of Deans, Departments, and even Industry - and probably because they seem capable of replacing us.

Graphics as a technology is admittedly a pretty static subject and after many years of teaching it produces a "retread" or even "burnout" syndrome. We may need a new challenge to inspire us and Computer Graphics appears to hold great potential in this regard for the aspiring graphician. In reality, this too may be an illusion. Almost any computer manufacturer can outstrip our research efforts in the prevailing financial atmosphere.

Many industrial supervisors will tell you - as they have me - that we should be teaching Computer Graphics, but more detailed discussion will disclose some important factors. First, only a few hours professionally, typically three or four weeks are needed to train a person to use a given computer graphics system. This is, of course, a trivial investment to the parent industry in view of the equipment expenditure. Second, absence of standards make it very difficult for a person to be proficient on more than one system, and such variation is a source of great concern to them, since it represents a possible introduction of human error into a system designed to reduce error. Virtually every system today is custom built and has its own pecularities. Third, every "new system" is a vast improvement over the "old" one both in capability and sophistication. The technology is moving at an astounding pace.

Each of these observations has impact on the feasibility of meaningful computer graphics in education and I stress "meaningful". First, in a typical Engineering curriculum, three or four weeks full-time training becomes 120 to 160 hours or at least 40 class hours. I leave it to you to determine the likelihood of creating around three credit hours for Computer Graphics in your curriculum without virtually eliminating your present course content. Moreover, the cost of providing enough terminals to give all your Engineering students this much "hands on" experience is staggering. It has been done, and proved so. Second, no matter what system you use in your school, the likelihood that your students will find the same system in employment is truly vanishingly small. Therefore their experience may be of little value except in the most pedantic view. Third, any system you provide to your students will be outdated within a year and you will quickly have a fleet of "Model T's" on your hands awaiting maintenance and replacement in a shrinking academic budget.

CONCLUSION

After all this you may find it peculiar that I still want to affirm my interest in and even wild enthusiastic endorsement of Computer Graphics, but only as an analytical tool of collossal strength and a documentation device of infinite patience and care. However, its proper place in the Engineering curriculum is at an "advanced" level and on a restricted basis to those who are interested and capable of pursuing it. Along that line, it would be logical to use Computer Graphics as a supplement and incentive for students who complete the essential graphics course material soon enough and well enough to qualify. Such a system would overcome most of the problems usually encountered because it would involve fewer students and require fewer terminals. Let's not forget, though, that the computer, and this is critical, is a TOOL and cannot communicate anything that its operator doesn't know initially. If we allow our course to be the electronic equivalent of a welding shop, you can be sure that the Time Hunters will soon show that they can make better use of the time spent there - and they will be correct.

Let's not ignore any of the tremendous tools that are at our disposal, but on the other hand, let's not be overcome by them, either. We must continue to seek higher knowledge in our field and convey that knowledge at the appropriate time to the appropriate people; but we must not forget that our product is people who can creatively, conscientiously, and responsibly analyze poorly defined problems, and visualize, synthesize, and communicate new and better solutions in view of a lifetime's experience.

Not one single one of those things can be done by a computer! On the other hand, we can and must begin to develop all those traits in our students by teaching - albeit more effectively - responsibility, neatness, punctuality, graphic communication and visualization. Certainly these are more important than mere ability to write commands on a keyboard! Our graduates should be professionals, not mediocre typists!

The first three of these - responsibility, neatness, punctuality - and others, to be sure, are habits and are approachable as such. The last two-graphic - communication and visualization - are technological and I am sure that we have not been addressing them as effectively as possible by compressing traditional courses. It is impossible to anticipate which applications of graphics a given student will need in the years ahead, but we can safely predict general needs, which means that we must systematically teach, develop, promote and assure both their ability to use graphics well with excellent sketches and graphs for future courses, and their ability to visualize, that is, the ability to create realistic two- and three-dimensional mental images and to use those images analytically. Bill VanderWall has developed and successfully used material on this subject at North Carolina State and several of our group have used the "blind sketching" method I described some time ago with positive and enthusiastic results. However, these are only first steps; more work is needed to develop methods for teaching and visualization.

We have all seen - and continue to see - our students arriving with only rudimentary ability to communicate their ideas effectively either to themselves or to others. We also know the importance of inner visualization and communication to an Engineer's career. "Thinking" takes place in pictures for most people, which to me means that better mental images produce clearer thought. TO VISUALIZE BETTER IS TO THINK BETTER. That is heady stuff; what higher calling can there be in education than to produce a large step change in thinking ability.

Such tremendous accomplishments are nothing to apologize for. Let's quit muttering to ourselves and do some public relations work. Take a positive attitude and make sure our peers know what we've done by virtue of our students' performance. Make sure our students know what we have done for them by virtue of their success -- and BRAG about it a little!

REEL TO REEL

A Report of the COMPUTER GRAPHICS Committee

CG as a Design Tool

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EDITOR'S NOTE: This paper was sent to the editor shortly after the 1979 Annual Meeting at Baton Rouge, at which this paper was presented at an EDGD sponsored event. Although, the material is over two years "cold", at the date of this publication, the Journal maintains that the trend has been indicated by this article, and challenges the readership to present an update to the Computer Graphics committee of the EDGD.

Abstract

This paper is the result of a study made by a subcommittee of the Computer Graphics Committee of the Graphics Division of the American Society for Engineering Education. Representatives of Industry and Education responded to a letter of inquiry sent by the authors requesting the use of Computer Graphics as a design tool at their respective organizations. The results of the respondants indicate that computer graphics is being used as a design tool to some extent by both industry and education.

Acknowledgment

The authors are deeply indebted to the representatives of both industry and education who responded to their inquiry and therefore wish to express their gratitude to those persons. Without their assistance this paper could not have been prepared.

INTRODUCTION

The digital computer has contributed greatly to the Engineering profession. It has reduced the time necessary in obtaining solutions to engineering problems. The versatility of the computer as a design tool is becoming more evident each year. Its adaptation to graphical display enhances its use as a design tool in industry and at educational institutions. The computer can be programmed to perform many functions, one being computer graphics. Just how much computer graphics is used as a design tool is not known. However, the desire to find out has initiated this study. A subcommittee of the Computer Graphics Committee of the Engineering Design Graphics Division of ASEE was given the re-

TABLE I. USE OF COMPUTER GRAPHICS IN EDUCATION

University	Comp. Graph. Application	Dep'ts. Using Comp. Graph.	Level of Student Instr.	Text Authors
Airforce Inst. of Tech.	Solutions	School of Engr.	Undergrad & Grad	Notes & Manuals
Alaska, U of	Sol. & Art.	CE., Eng. Sci.	Fresh.	Notes & Manuals
Arizona, U of	Solutions	Aero., ME., CE.	Undergrad & Grad	Newman & Sproull[6]
Bridgeport, U of	Solutions	EE., ME.	Sr. & Grad.	Newman & Sproull[6]
British Columbia, U of	Solutions	CE.	Sr.	Notes & Manuals
Calif. State U.-Long Beach	Solutions	ME. & others	Soph., Jr., Sr., Grad.	Notes & Manuals
Calif. U. of Davis	Solutions	ME., CE.	Fresh., Sr., Grad.	Notes & Manuals
City Univ. of New York	Solutions	CE.	Undergrad. & Grad.	Notes & Manuals
Clemson U.	Solutions	Eng. Graphics	Fresh., Jr., Sr.	Daniel Ryan[2] & Wolfgang Giloi[4]
Concordia U.	Sol. & Art.	CE.	Adv. undergrad. & Grad.	Notes & Manuals
Connecticut, U of	Solutions	Eng. Graph., ME.	Fresh., Soph., Sr., Grad.	Newman & Sproull[6]
Dayton, U of	Solutions	ME.	Sr., & Grad.	Notes & Manuals
Florida Inst. of Tech.	Solutions	Math. Sci. Dep't.	Undergrad. & Grad	Newman & Sproull[6] Wolfgang Giloi[4]
Georgia Inst. of Tech.	Solutions	C.S., EE., ME.	Sr., Grad.	Newman & Sproull[6]
Harvard U.	Sol. & Art.	Architecture	Grad.	Rogers & Adams[5] Newman & Sproull[6] Parslow, Prouse, Green[3]
Illinois Inst. of Tech.	Solutions	All Eng. Dep'ts.	Jr., Sr., Grad.	Notes & Manuals
Illinois, U of Urbana-Champ.	Solutions	Aero., Met., ME., G.E.	Soph., Jr., Sr.	Notes & Manuals
Kansas, U of	Sol. & Art.	ME., C.S., CE., Pet. E.	Jr.	Notes & Manuals
Louisiana Tech. U.	Solutions	ME.	Jr., Sr., Grad.	Notes & Manuals
Maryland, U of	Solutions	EE.	Upper level	Notes & Manuals
Michigan State U.	Solutions	ME.	Soph., Jr., Sr., Grad.	Rogers & Adams[5]
Michigan Tech. U.	Solutions	ME., EM.	Fresh., Sr.,	Rogers & Adams[5]
Missouri, U of - Columbia	Solutions	Mech. & Aero. Eng.	Soph., Jr., Sr.	Notes & Manuals
Missouri, U of - Rolla	Solutions	Aero., CE., Chem.E., EM., ME.	Soph., Jr.	Notes & Manuals
Nebraska, U of - Lincoln	Sol. & Art.	ME., CE., IE., EE.	Fresh., Sr.	DeLorm & Kersten[1]
New Brunswick, U of	Solutions	ME.	Sr.	Notes & Manuals
North Carolina State U.	Solutions	EE., GE., C.S.	Jr., Sr.,	Notes & Manuals
Northwestern U.	Solutions	Chem. Eng.	Grad.	Notes & Manuals
Oakland U.	Solutions	Unknown	Upper level	Notes & Manuals
Oklahoma State U.	Solutions	School of Tech.	Fresh., Soph., Jr., Sr.	Notes & Manuals
Ohio U.	Solutions	Eng. Graphics	Fresh.	Notes & Manuals
Pennsylvania, U of	Sol. & Art.	C. & Urban Eng. C.S.	Soph., Jr., Grad	Newman & Sproull[6] Rogers & Adams[5]
Purdue U.	Sol. & Art.	ME.	Upper level, Grad.	Newman & Sproull[6] Rogers & Adams[5]
Rochester, U of	Solutions	EE., ME.	Sr. & Grad.	Notes & Manuals
Rose-Hulman Inst. of Tech.	Solutions	Eng. Design	Undergrad.	Notes & Manuals
South Dakota State U.	Solutions	G.E.	Fresh.	Notes & Manuals
Southeastern Mass. U.	Sol. & Art.	EE., Math.	Fresh., Grad.	Notes & Manuals
Stevens Inst. of Tech.	Solutions	CE., Chem., Phys., Econ.	Soph., Jr., Sr.	Notes & Manuals
Tennessee Tech. U.	Solutions	Eng. Sc. & Mech.	Jr., Grad.	Notes & Manuals
Texas, U of - at Austin	Solutions	ME.	Fresh., Soph.	Notes & Manuals
Toronto, U of	Solutions	ME., CCED	Undergrad. & Grad.	Notes & Manuals
Tuskegee Inst.	Sol. & Art.	EE.	Sr., Grad.	W. R. Bennet[7]
U.S. Coast Guard Academy	Solutions	Dep't of Appl. Sc. & Eng.	Jr., Sr.	Notes & Manuals
Vermont, U of	Solutions	CE.	Soph., Jr., Sr.	Notes & Manuals
Virginia, U of	Solutions	ME., Comp. Sc.	Jr., Sr., Grad.	Notes & Manuals
Western Michigan U.	Solutions	IE., Eng. Graph.	Sr.	Notes & Manuals
Wisconsin, U of - Madison	Sol. & Art.	G. E., ME., CE.	Fresh., Soph., Jr., Grad.	Notes & Manuals
Wisconsin, U of - Milwaukee	Sol. & Art.	Syst. Des. Dep't.	Fresh., Grad.	Notes & Manuals

sponsibility of contacting representatives of industry and education to ascertain the extent to which computer graphics is being used as a design tool. Members of the subcommittee were Mr. Thomas C. Smith, Professor of Engineering Mechanics, University of Nebraska-Lincoln, and the authors of this paper.

This paper is the result of a two-phase informational request which the authors initiated. Part I contains information concerning the use of computer graphics as a design tool at several Colleges and Universities located in the United States and Canada. Part II contains information concerning the use of computer graphics as a design tool. It is only an initial effort to ascertain its use as demonstrated by the response to letters sent by the authors to 225 Universities and 100 representatives of industry. 75 Universities and 47 representatives from industry responded to the authors' request. The results of the response from both industry and education are included in this paper.

COMPUTER GRAPHICS AS A DESIGN TOOL IN EDUCATION

A letter of inquiry was sent to 225 Universities located in the United States and Canada. The letter included questions concerning the use of computer graphics as a design tool in Engineering Education. The following four questions were asked:

1. How is computer graphics being utilized at your institution; as a solution tool, or is it art related?
2. In what departmental courses is it being utilized?
3. At what level of instruction. (i.e., freshman, sophomore, graduate, etc.) is it being presented?
4. What texts and/or supplementary materials are used?

Of the 75 universities which responded, 28 indicated that computer graphics was not being used as a design tool at their institution. Forty-seven universities indicated that they were using computer graphics either as a solution to problems or as a tool in graphics art. Table 1 represents the results as indicated by the response from those universities who are using computer graphics as a design tool.

In most cases a specific text was not being used and either departmental notes and/or computer manufacturers manuals were used as texts. Some indicated they were using software packages from computer manufacturers in association with manuals and notes.

The most popular text that was being used was, Principles of Interactive Graphics by Newman and Sproull. The second most popular text was Mathematical Elements for Computer Graphics by Rogers and Adams. A list of all texts indicated is included in the appendix and referred to by reference number in the table.

COMPUTER GRAPHICS AS A DESIGN TOOL IN INDUSTRY

A letter of inquiry was also sent to 100 corporations located throughout the United States. A wide variety of different types of industry were contacted through the letters. The types of industry include the automotive, oil, aircraft, shipbuilding, food processing, chemical, and engineering consulting. The corporations contacted were, in general, the larger companies found in the country. The letter sent to the companies asked if computer graphics were used in design and if graphics were used, how they were used.

Of the 100 letters sent, there were 47 responses. Twelve companies indicated that computer graphics were not used in their design work. Two of the twelve companies indicated that they were planning to incorporate computer graphics into their engineering departments sometime in the next year. Five of the companies said that a very small part of their design work was done in-house and computer graphics would not be practical for their work. The remaining companies indicated that computer graphics were not compatible with their work or that they simply did not use computer graphics. Computer graphics was used at 35 of the companies responding to our letter. There were several uses of computer graphics. The most common uses were computer aided drafting and computer aided manufacturing. Other uses included finite element modelling, material testing for corrosion, weld inspection, contour mapping, equipment and plant layout, seismic charting and several others. A complete list of companies who responded and some of the uses of computer graphics in design is given in Table II. Itshouldbe noted that the uses of computer graphics listed in Table II are only those given in letters of reply. Some are specific uses -- some are general uses.

COMMENTS AND CONCLUSIONS

The results of the study indicate that Computer Graphics is being used as a design tool by engineering students. Several of the letters received from universities which, at the time, were not using computer graphics suggested that they were planning to include it in the engineering curriculum at some future time. The main reason

TABLE II. USE OF COMPUTER GRAPHICS in INDUSTRY

Industry	Application
Bechtel	Computer aid design in nuclear power plant work, Finite element interactive graphics, Generalized contour mapping program, Computer aided drafting
Bendix	Automated drafting in: Schematics PC Board layouts LSI Design Automated design in: Gear train design Simulation work
Bethlehem Steel	Computer aided manufacturing Computer aided lofting
Black & Veatch	Not used
Boeing Computer	Computer aided drafting Computer aided manufacturing
Brown & Root	Computer aided drafting
Chrysler	Computer manikin to forecast the reaction of people
Coca Cola	Not used
Conoco	Design of off-shore structures Line drawings
Corn Products	Not used
Dow Chemical	Not used
DuPont	Computer aided pipe sketches Code diagrams Graphical representation of information for design Equipment arrangement drawings Plotting
Exxon	Preparation and updating of piping diagrams Visual display of structural members Mapping of open pit mines
Firestone	Equipment and plant layout work
Fisher Controls	Electronic P/C board design Computer aided drafting Design layout Finite element modeling Seismic charting
General Dynamics Convair Division	Computer aided design Computer aided drafting
General Dynamics Electric Boat Division	Computer aided drafting Finite element modeling Non-destructive ultrasonic testing Computer aided manufacturing
General Dynamics Quincy Shipbuilding Division	Computer aided drafting Computer aided manufacturing Optimizing nesting of structural parts
General Motors	Preperation of body surface shapes
Georgia Pacific	Not used
Goodyear	Not used
Indiand Steel	Design and manufacturing of rolls (used to shape steel)
International Harvester	Computer aided design Computer aided manufacturing
Kodak	Computer aided drafting
Kraft	Not used
Mobil	Not used
Monsanto	Design of tracking device Pollution abatement design studies
Owens-Illinois	Computer aided design Computer aided drafting
Phillips Petroleum	Automated drafting Computerized image generator
Ralston Purina	Not used
Republic Steel	Automated drafting Automated design Computer aided manufacturing
Rockwell International Automotive Operations	Computer aided design Finite element modeling Detail drafting Manufacturing
Rockwell International Graphic Systems Division	Computer aided drafting
Sandia Laboratories	Computer aided design Computer aided drafting Analysis Computer aided manufacturing
Standard Oil (Indiana)	Genigraphics Geological/Geophysical drawings Computerized drafting
Suntech Group	Computer aided drafting
Tennessee Gas Pipeline	Computer aided drafting Computer aided analysis and design
Texaco	Computer aided drafting Structural design
Union Oil	Not used
Uniroyal	Computer aided drafting Computer aided manufacturing
United Technologies Pratt & Whitney	Computer aided drafting and design Computer aided manufacturing
Warner Lambert	Not used
Westinghouse	Computer aided design

that it was not being used was the cost of computer equipment necessary for teaching computer graphics. Several indicated that as soon as finances were available, they would be using computer graphics as a method of instruction in the process of design.

The tabulated results also indicated that computer graphics was being taught at all class levels including graduate. Judging from the information received, computer graphics is an important part of the engineering curriculum and provides a ready tool which the student can utilize in developing and/or improving the design process.

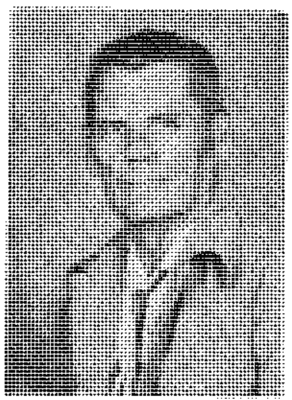
The utilization of computer graphics in the undergraduate and graduate curriculum introduces the student to modern methods of designing structures and machines and also affords the student the opportunity to expand his artistic abilities in graphically representing ideas which relate to design. Many of those responding favorably to the author's letter accompanied their response with written materials which they were using in teaching design concepts.

The results of the study also show that computer graphics are used in industry. Although several companies have been using computer graphics for years many of the companies indicated that they have just recently installed computer graphics at their facilities. Many of the companies who have recently installed computer graphics indicated they were still training their people in the uses and have not yet reached the full potential of their facilities.

APPENDIX A

1. Calcomp Programing for Digital Plotters - DeLorm & Kersten
2. Computer-Aided Graphics & Design - Daniel Ryan
3. Computer Graphics Techniques & Applications - Parslow, Prouse & Green
4. Interactive Computer Graphics - Wolfgang Giloi
5. Mathematical Elements for Computer Graphics - Rogers & Adams
6. Principles of Interactive Graphics - Newman & Sproull
7. Scientific & Engineering Problem Solving With the Computer - W. R. Bennet

ENGINEERING GRAPHICS REQUIREMENTS NOW!



L. WYMAN V. VALDEZ

ENGINEERING GRAPHICS DEPARTMENT
S.D. SCHOOL OF MINES AND TECHNOLOGY

The above named were faced with a problem; specifically, the "average" Engineering Graphics requirements (credits and content) required for a Bachelor of Science Degree in an engineering discipline at the ECPD accredited colleges and universities.

Without an available answer, and not inclined to peruse each department requirements in 189 college catalogs (many of which were not available) - this survey was started in the Fall and returns are considered closed.

Historically, surveys and questionnaires continue to exist for various reasons and purposes:

- An effort to prove or disprove one's personal opinions
- A resource material for dissertations, etc.
- Mandated by upper echelons in the hierarchy of command
- Desire to emulate offerings of prestige peer groups

*- A sincere interest in results requested

Surveys are designed, or occur, in various formats:

- Loaded with biased questions (heads I win - tails you lose)
- Essay requests requiring much research and personal effort.
- Multi-page epistles which attest to authors skill in mathematical statistics and random probabilities.
- Multi-page inquiries designed with each consideration to be rated on the magic 1-10 scale. Rationale and beauty of this category is that it will provide reams of "input" to the computer with resulting genuine, honest to goodness, 10 decimal place accuracy of irrefuteable validity.

*- Shortened form with requests for information.

This survey was prompted by the asterisk (*) items above. In the "design" phase of the survey, the principle parameters were: what, why, and who.

What - information concerning Engineering Graphics requirements (content and credit hours) required for a B. S. degree in an engineering discipline.

Why - for comparison purposes of material and content with our own institution.

Who - mailings to 189 similar institutions listed in the ECPD Accredited Programs Leading to Degrees in Engineering, 1977. Mailings were limited to this peer group for correlation purposes.

The survey was written in October 1979, and mailed in November 1979. Returns arrived at rapid rate during December and again in late January (as one kindred soul stated he only attempted to clean his desk during the Christmas break). Anonymity was intended and will be maintained. As our return envelopes were pre-franked at local postal service, nearly one half of returns were uncancelled by mailing station. We have received 140 returns for a return ration of 74%.

Resulting "Averages" are indicated on the Survey. All quarter hour credits were converted (2/3) to semester hours for averages. If the survey mailed to your institution is "lost on your desk, or in your circular file," please feel free to compare your content and requirements.

With all results averaged in percentages, much information and indications can be gathered from written comments and noting interplay between certain questions. The following is an attempt to arrive at overall picture (graphics term) or condensation of the written comments.

1. Of the 12% of schools with prerequisites for Freshman Engineering Graphics - large majority required Trigonometry.

2. Question should have included a zero category. A very interesting correlation developed between Question #2 and Question #7 (see survey).
   Of the 11% (15 schools) responding zero Engineering Graphics, 67% (10 schools) indicated yes to Question #7 favoring increased Engineering Graphics requirements. Other comments in the 11% group indicated the "topic" was "covered" in an Engineering Fundamentals type course, or on a "need to know" basis.

3. Question should have included a zero category and a blank space for numbers larger than five. (Largest number of required Engineering Graphics credits was 9 semester hours at an institution.)

4. Question would have been very lengthy and involved to clarify which departments required added credits in Engineering Graphics. Of 46% answering "yes", preponderance were Mechanical Engineering Departments with much fewer being Civil Engineering Departments.

5. Man of the 51% "no" answers indicated some of Descriptive Geometry materials were covered in integrated Engineering Graphics courses (see question 8).

6. Question should have been reworded to indicate if elective Engineering Graphics course credits qualified for departmental graduation total hour requirements.

7. Written comments on this question ranged from terse descriptive adjectives to full page letters. It was interesting to note that of the 35% answering "no"; these institutions required an average of 3.22 semester hours in Engineering Graphics. Also note comments on Question #2.

8. Of the 12% listing design oriented, many indicated it was either an upper level course or a "final project" type application in the second Engineering Graphics course.
   - computer based, two schools had adopted and discarded; three schools were going to offer to selected groups on trial basis in 80-81 terms; three schools offered a portion of second required Engineering Graphics course as computer oriented; only one school checked "computer based".

The last line of survey welcoming comments (and Question #7) produced many interesting, constructive, "suggestive", etc. comments and full page letters. Comments ranged from: "Our seniors can't draw," to "Industry complains our B. S. grads can't draw or read drawings" (this one with request from very large manufacturing company for a course outline in Engineering Graphics to use for their "new hires"). Also included were "Don't rock the boat," "Nobody cares," "Don't follow our downhill path," and some that could not be repeated in any form or fashion.

SOUTH DAKOTA SCHOOL OF MINES
AND TECHNOLOGY

RAPID CITY, SOUTH DAKOTA 57701

SAMPLE SURVEY FORM
(W/ NAT'L. AVERAGES)
(IN PERCENTAGE OF RETURNS)

Engineering Graphics Dept. Head:

Dear Sir/Ms:

Please do not groan or swear at this survey. A minimum of your time will result in valuable information for both (all) of us.

Consideration: An "average" of required Engr. Graphics credits for a B.S. degree in Engineering.

Please complete the following with a checkmark or circle. (Comments on each are welcome, but not required).

1. Are there any prerequisites for your 1st Freshman Engr. Graphics course (H.S. credits, or???)? If so, please clarify. — 12% Yes No 88%
2. Number of courses in E.G. required for B.S. in Engr.? 1 2 3 — 0=11% 1=67% 2=22% 3=3%
3. Total credit hrs in E.G. required for B.S. in Engr.? 1 2 3 4 5 Sem 2.42 Qtr____
4. Do requirements in E.G. vary for your various engineering options? — 46% Yes No 54%
5. Is descriptive geometry (under any new or old title) required for B.S. in Engr.? — 49% Yes No 51%
6. Courses available in non required E.G. electives? — 45% Yes No 55%
7. Do you personally favor more E.G. requirements? — 65% Yes No 35%
8. Your evaluation of your present offerings in required E.G. course(s). (Circle)
   - Traditional 55%
   - Integrated 22%
   - Other NONE REQ 11%
   - Design oriented 12%
   - Computer based LESS THAN 1%

Any comments are most welcome. Please enclose a self-addressed, stamped envelope for results.

Sincerely,

L. Wyman, Head Engr. Graphics

LW/nls

Three letters mentioned previous surveys:

1. "Results of our survey was that no-one was happy with their present graphics program," "Industry has also indicated in our area that graduates are not well founded in graphics and we are considering redoubling our program."

2. "Should Engineering Graphics remain a part of the formal B. S. Degree curriculum? Yes = 92%. Amount of course work required? 2 or more two semester hour credit courses."

3. A well known person in Engineering and in the Graphics area noted: "I ran such a survey several years ago - average required 4.6 semester hours all undergraduates and 6.9 semester hours average for Mechanical Engineering students."

The survey should have included at least two more items: Classification of the Engineering Graphics Department (separate service department or subsidiary of Civil Engineering, Mechanical Engineering, etc.) - and were faculty teaching Engineering Graphics full time, or just part time with main interest in other fields. Also any industrial experience and total hours credits in Engineering Graphics instructors had received.

Conlusion: Surveys and summaries require much more effort than imagined before starting same. If moved to attempt another, may we please be lucky and sprain both ankles instead. Many thanks for the 74% returns and especially the many letters.

ENGLISH TO SI

A REPORT OF THE METRICATION COMMITTEE

The following bibliography was furnished by Ed V. Mochel, chair of the Metrication committee. This column is a new feature of the Journal. Contact Ed if you wish to contribute.

1. ASTM Standard for Metric Practice E380-79, $4.00, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103

2. ASME Orientation and Guide for Use of SI (Metric) Units, 8th Ed., 1978, E00082, American Society of Mechanical Engineers, $2.00, 345 E. 47th Street, New York, New York 10017

3. Metric Screw Threads - M Profile, ANSI B1.13M-1979, $10.00, American National Standard Institute, 1930 Broadway, New York, New York 10018

4. The International System of Units, E. A. Mechtly, 1977, $1.20, Stipes Publishing Co., 10 Chester Street, Champaign, Illinois 61820

5. SI Metric Units: An Introduction, H. F. R. Adams, 1974, $3.95, McGraw-Hill Book Co., 1221 Avenue of the Americas, New York, New York 10020

6. Recommended Guidelines for Company Metrication Programs in the Metal-working Industry, HS1-1066, 1974, $6.50, Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096

7. American National Metric Council Metric Editorial Guide, 3rd Ed., $1.75, American National Metric Council, 1625 Massachusetts Avenue, Washington, D.C. 20036

8. Metric Units of Measure and Style Guide, $1.00, U.S. Metric Association, Inc., 796 Alameda Street, Altadena, California 91001

9. The International System of Units (SI), NBS Special Publication 330, C13:304A $.50, Supt. of Documents, U.S. Government Printing Office, Washington, D.C. 20402

10. World Metric Standards for Engineering, K. O. Kverneland, $40.00, Knut O. Kverneland, 2990 Welch Road, Walled Lake, MI 48008

11. Reference Handbook for Proper Use of Metric - SI in Science and Engineering, R. C. Sellers, 1974, $1.95, Robert C. Sellers & Assoc., Inc. Floral Park, New York 11002

12. Successful Experiences in Teaching Metric, NBS Special Publication 441, $2.30

13. Physical Measurements and the International System of Units, R. A. Ackley, $1.75, 1970, Technical Publications, Box 17324, San Diego, California, 92117

file to file

Many "on the line" teachers have ideas, suggestions, techniques, problems and questions they would like to share with the society. "File to File" provides the place for exchange of professional information. If you have an item for exchange, submit it to "File to File", EDGD Journal, PO Drawer HT, Miss State, MS, 39762.

Finding Stress and Deformation in a Shaft Graphically

> When this paper was reviewed, the reviewer commented that a college sophomore should be able to perform the analytical and graphical tasks presented herein. However, since some of us are involved in teaching problem solutions for engineering to college freshmen and to engineering technology majors, it is felt that this material may refresh our memories and offer a few more possibilities in this area.--Ed.

LYNDON O. BARTON
E. I. DUPONT DE NEMOURS & CO., INC.
WILMINGTON, DE

INTRODUCTION

Frequently, the amount of stress or deformation in a segment of a shaft (or structural member) subjected to multiple loading is of paramount importance to a machine or structural designer.

The standard approach used to determine such stresses and deformations is to divide the shaft into individual segments according to the applied loads and analyze each segment as a free body. But this approach can be tedious particularly if several loads are involved. On the other hand, it is not uncommon for the unwary designer, in an effort to avoid the free body approach, to apply the wrong loadings for segments being analyzed.

SCOPE

This paper describes a quicker and more positive approach to the solution of the multi-loaded shaft problem, in which use is made of a graphical technique, similar to that generally employed in the development of shear diagrams in beams. This technique is best illustrated in the following two examples where the stresses and deformations in shaft sections are determined for torsional and axial loadings.

EXAMPLE

The steel shaft ABCD shown in Figure 1 is subjected to torsional loading at A, B, C, and D. Determine the resisting torque, shear stress, and angle of twist in segments AB, BC, and CD.

PROCEDURE

1. Determine the unknown resisting torque T_D from algebraic sum of clockwise (CW) and counterclockwise (CCW) torques, assuming that clockwise torques (looking from right to left) are positive and counterclockwise torques are negative. Equating CW torques with CCW torques, one obtains

$$T_D + T_B = T_C + T_A$$

$$T = 50{,}000+5{,}000-35{,}000$$

$$= \underline{20{,}000 \text{ in-lb}}$$

2. With all positive and negative torques completely defined, develop a modified load diagram (Figure 2)

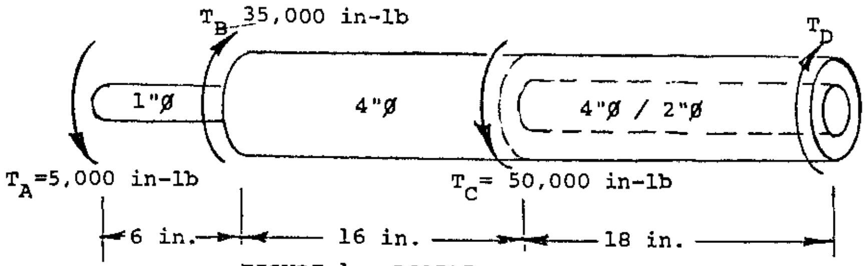


FIGURE 1 - LOADED MEMBER

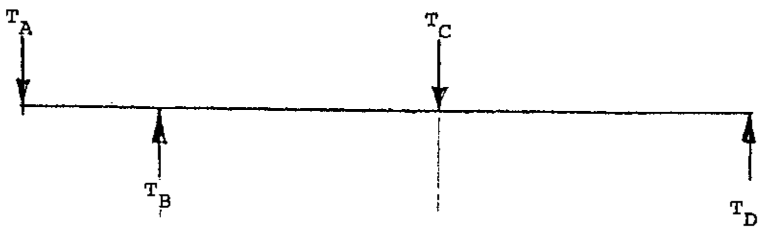


FIGURE 2 - MODIFIED LOADING DIAGRAM

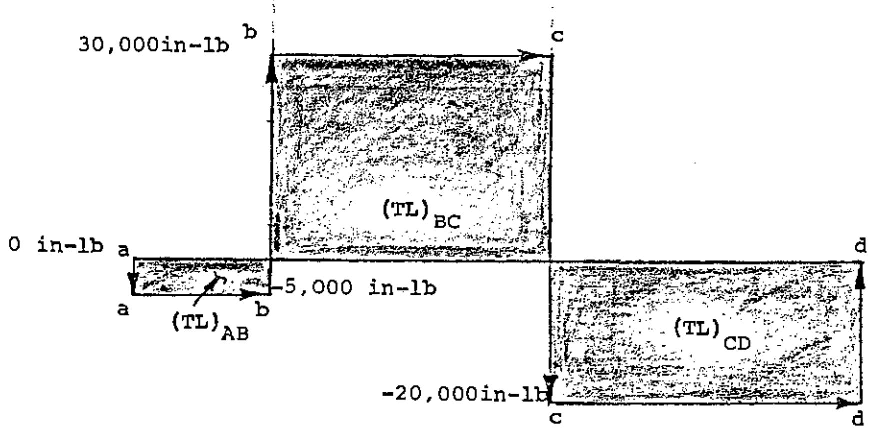


FIGURE 3 - TORQUE DIAGRAM

for the shaft ABCD, showing the torque loadings T_A , T_B , T_C , and T_D at points A, B, C, and D as concentrated loads at those points (Figure 2).

3. Starting at the left end of the shaft, draw base line ad for torque diagram (Figure 3) under the modified loading diagram.

4. The torque T_A is down, so draw aa down to scale to represent the torque at A (5,000 in-lb).

5. Since there is no other torque until T_B, draw ab horizontal so that b is in line with T_B.

6. T_B is upward, so draw bb upward to scale to represent T_B (35,000 in-lb).

7. Since there is no other torque until T_C, draw bc horizontal so that c is in line with T_C.

8. T_C acts down, so draw cc downward to scale to represent T_C(50,000 in-lb).

9. Since there is no other torque until T_D, draw cd horizontal so that d is in line with T_D.

10. T_D is upward, so draw dd upward to scale to represent T_D(20,000 in-lb).

The torque diagram should now be closed.

DETERMINATION OF SHEAR STRESS

Now that the torque diagram is complete, the resisting torques in the various segments of the shaft can be readily visualized from the graphic information. For example,

Torque in segment AB (T_{AB}) = 5000 in-lb

Torque in segment BC (T_{BC}) = 30000 in-lb

Torque in segment CD (T_{CD}) = 20000 in-lb

Thus, the shear stress in each segment is obtained as follows:

$$\tau_{AB} = \left[\frac{Tc}{J}\right]_{AB} = \frac{(5000)\ (0.5)\ 32}{\pi(1)^4}$$

$$= \underline{25{,}500\ \text{psi}}$$

$$\tau_{BC} = \left[\frac{Tc}{J}\right]_{BC} = \frac{(30000)\ (2)\ 32}{\pi\ (4)^4}$$

$$= \underline{2390\ \text{psi}}$$

$$\tau_{CD} = \left[\frac{Tc}{J}\right]_{CD} = \frac{(20000)\ (2)\ 32}{\pi(4^4 - 2^4)}$$

$$= \underline{1700\ \text{psi}}$$

DETERMINATION OF DEFORMATION

To determine the deformation or twist in each segment, it should be noted that the shaded areas, bounded in part by the base line ad, define the products $(TL)_{AB}$, $(TL)_{BC}$, and $(TL)_{CD}$ which are directly applicable to the twist equation,

$$\theta = \frac{T\ L}{G\ J},$$

as follows:

$$\theta_{AB} = \left[\frac{TL}{GJ}\right]_{AB} = \frac{(5000)(6)(32)}{(12 \times 10^6)(\pi)(1.0)^4}$$

$$= \underline{0.025\ \text{rad. (or } 1.45^\circ)}$$

$$\theta_{BC} = \left[\frac{TL}{GJ}\right]_{BC} = \frac{(30000)(16)(32)}{(12 \times 10^6)(\pi)(4)^4}$$

$$= \underline{0.0016\ \text{rad. (or } 0.09^\circ)}$$

$$\theta_{CD} = \left[\frac{TL}{GJ}\right]_{CD} = \frac{(20000)(18)(32)}{(12 \times 10^6)(\pi)(4^4 - 2^4)}$$

$$= \underline{0.0013\ \text{rad. (or } 0.07^\circ)}$$

EXAMPLE 2

The steel shaft ABCD shown in Figure 4 is subjected to axial loading at points A B, C, and D. Determine the axial stress and deformation in each segment (AB, BC and CD).

PROCEDURE

As one might assume from the analogy between angular and linear deformation expressions namely,

$$\theta = \left[\frac{TL}{GJ}\right] \quad \text{and} \quad \delta = \left[\frac{FL}{AE}\right]$$

The solution procedure for this example is the same as that used in Example 1, except that in order to develop the modified loading diagram (Figure 5), it is necessary to assume that forces directed to the right are positive and upward, and forces to left are negative and downward.

Accordingly, the force diagram (Figure 6) is developed and the effective loading for the various segments namely, F_{AB}, F_{BC}, and F_{CD} are readily obtained. Thus, the required stresses are:

$$\sigma_{AB} = \left[\frac{F}{A}\right]_{AB} = \frac{(4000)}{(0.785)(0.75)^2}$$

$$= \underline{9059\ \text{psi}}$$

$$\sigma_{BC} = \left[\frac{F}{A}\right]_{BC} = \frac{(6000)}{(0.785)(0.5)^2}$$

$$= \underline{30{,}573\ \text{psi}}$$

$$\sigma_{CD} = \left[\frac{F}{A}\right]_{CD} = \frac{(1000)}{(0.785)(0.25)^2}$$

$$= \underline{20{,}382\ \text{psi}}$$

And the required deformations are as follows:

$$\delta_{AB} = \left[\frac{FL}{AE}\right]_{AB} = \frac{(4000)(6)}{(0.785)(0.75)^2(30\text{x}10^6)}$$

$$= \underline{0.0018\ \text{in.}}$$

$$\delta_{BC} = \left[\frac{FL}{AE}\right]_{BC} = \frac{(6000)(16)}{(0.785)(0.5)^2(30\text{x}10^6)}$$

$$= \underline{0.0163\ \text{in.}}$$

$$\delta_{CD} = \left[\frac{FL}{AE}\right]_{CD} = \frac{(1000)(12)}{(0.785)(0.25)^2(30\text{x}10^6)}$$

$$= \underline{0.0082\ \text{in.}}$$

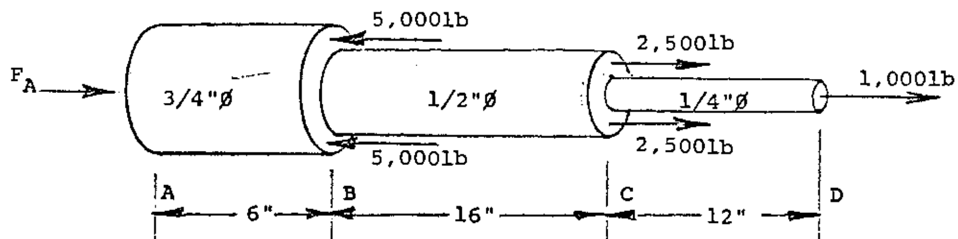


FIGURE 4 - LOADED MEMBER

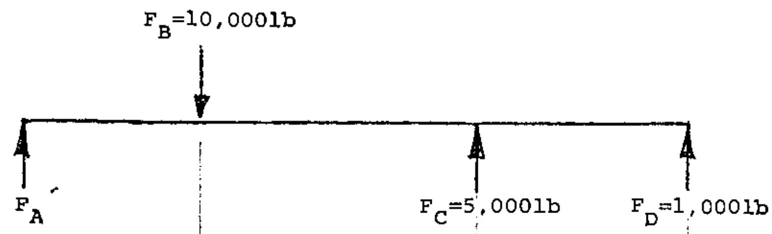


FIGURE 5 - MODIFIED LOADING DIAGRAM

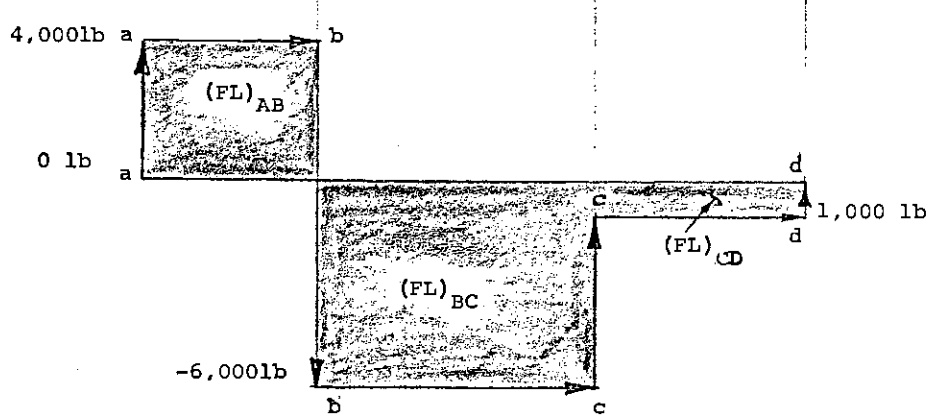


FIGURE 6 - FORCE DIAGRAM

NOMENCLATURE

A - Area of cross-section (in.^{2})

E - Modulus of elasticity (for steel, $E = 30x10^6$ psi)

c - Distance of outer fiber from neutral axis (in.)

F - Force (lb)

G - Modulus of rigidity (for steel, $G = 12x10^6$ psi)

J - Polar moment of inertia of cross-section (in^4)

L - Length of segment (in.)

T - Torque (in-lb)

GREEK SYMBOLS

θ (theta) - Angle of twist (radians)

δ (delta) - Deformation (in.)

τ (tau) - Shear Stress (psi)

σ (sigma) - Tensile or compressive stress (psi)

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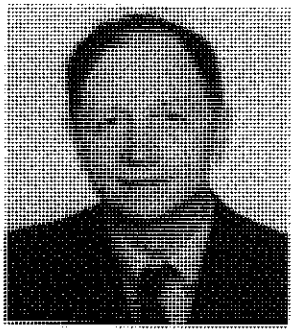
GRAPHICAL SOLUTIONS IN STRUCTURAL DESIGN



KARL RAETHE
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CANADA

It may be argued that graphic statics and vector analysis is superseded by mathematics until one discovers that no analytical solution can match the simplicity of graphical solutions for statically indeterminate structures. Accurate mathematical solutions for continuous beams and frames are complex and unpopular. Even the national design codes recognize this and approve of approximations and simplified formulas, the use of which by a novice without a sound professional judgement can be dangerous considering the infinite variety of span length combinations and loading conditions possible.

In spite of this fact the author knows of no textbook which covers these simple graphical methods which he used during many years of professional practice in structural engineering design, checking, and preparing computer input data. Much of it was developed from memories, from notebooks made in European schools during the earlier part of this century and from experience. A two-part article on the subject exists in the Engineering News Record of May 4 and June 1, 1944 by D.B. Steinman, the only reference sofar discovered.

All of the exercises may be checked by simple geometry. The formulas used are known as handbook data or developed from such information to support the geometry which could stand entirely on its own without such support. It is provided for the benefit of those who prefer to follow the procedure along algebraic lines.

The degree of restraint or fixity at the different supports or junctions of a continuous structure is the result

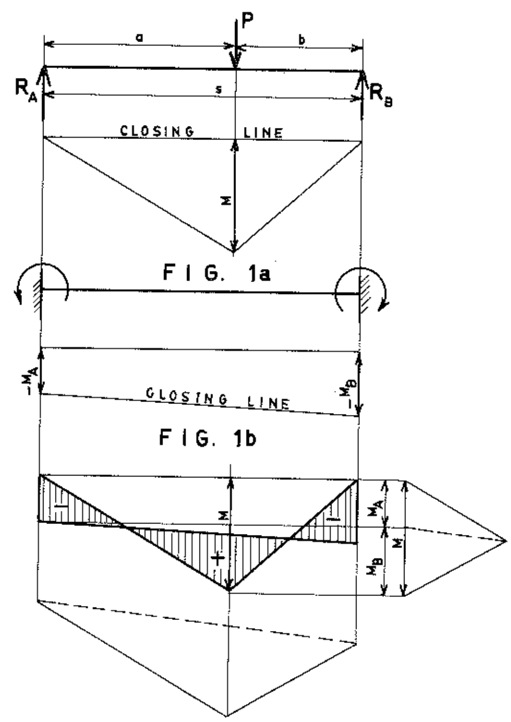


FIG. 1a

FIG. 1b

FIG. 1c

of the interactions of all its members in proportion to their respective stiffness relations.

The solution requires two steps:

1. To find the fixed-end moments at the supports for each independent single span (covered in this article).

2. To balance or distribute the moments so arrived at over the whole system to achieve static e equilibrium (covered in a second article.)

FIXED END MOMENTS

For a single point load on a simply-supported beam as in Figure 1a the bending moment diagram is a triangle of positive bending-moments having an altitude of M and a base of s.

For such a beam having fixed-ends the effect of the fixed-end moments is represented by a bending-moment diagram that is a trapezoid of negative moments only (Fig. 1b).

$$(-M_A) = \frac{M\ b}{s} = \frac{P\ a\ b^2}{s^2}$$

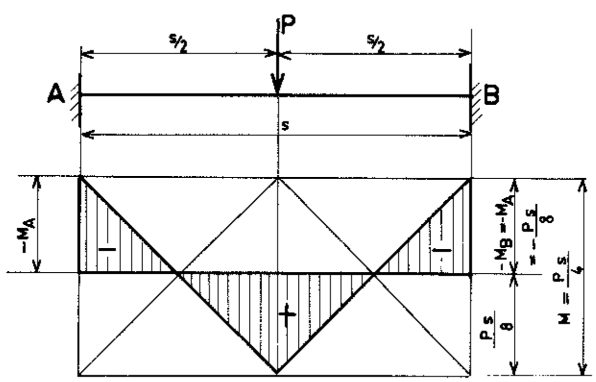
$$(-M_B) = \frac{M\ a}{s} = \frac{P\ a^2\ b}{s^2}$$

Since

$$(R_A) = \frac{P\ b}{s} \quad \text{and} \quad (R_B) = \frac{P\ a}{s}$$

we establish the relation

$$\frac{(-M_A)}{M} = \frac{(R_A)}{P} \quad \text{and} \quad \frac{(-M_B)}{M} = \frac{(R_B)}{P} .$$



F I G. 2

Conclusion: In a vector diagram using 'M' instead of 'P', the closing line will divide 'M' into $(-M_A)$ and $(-M_B)$, Fig. 1c. Further, it can be seen that the areas of the triangle and the trapezoid are equal.

$$A = \tfrac{1}{2}\ s\ M = \tfrac{1}{2}\ s\ \left\{(-M_A) + (-M_B)\right\} .$$

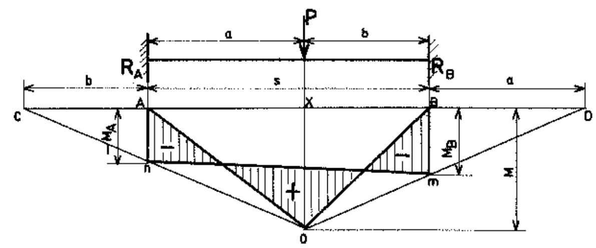
Since

$$(-M_A)\ s = M\ b \quad ; \quad \frac{(-M_A)}{b} = \frac{M}{s}$$

and

$$(-M_B)\ s = M\ a \quad ; \quad \frac{(-M_B)}{a} = \frac{M}{s} ,$$

we may use the graphical solution shown in Figure 3 instead of drawing a vector diagram.



F I G. 3

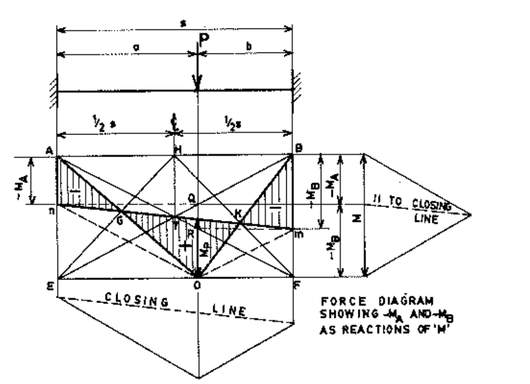
The familiar example of a single concentration in the centre of the span (Figure 2) is self-explanatory where

$$(-M_A) + (-M_B) = \frac{P\ s}{8} + \frac{P\ s}{8} = \frac{P\ s}{4} .$$

Figure 4 shows some other geometric relations indicating different approaches to graphical solutions of the problem.

1. The diagonals A-F and E-B are the influence lines for $(-M_A)$ and $(-M_B)$ respectively therefore we find R-m and Q-n.

2. T-A-H and n-E-O are similar triangles giving $(-M_A)$ and so are T-H-B and O-F-m giving $(-M_B)$. This similarity also proves;



F I G. 4

3. the intersection of lines E-H and A-O at 'G' and of lines H-F and B-O at 'K' are points on the closing line which is established by extending G-K to n, producing $(-M_A)$ and to m, producing $(-M_B)$.

Note that line E-F must be parallel to line A-B.

The graphical solution for two concentrations is shown in Figure 5.

1. Draw the moment diagram A-B-H-G-A for the simple supported span. Extend G-H to E and F.

2. Draw either diagonal E-B or A-F or both.*

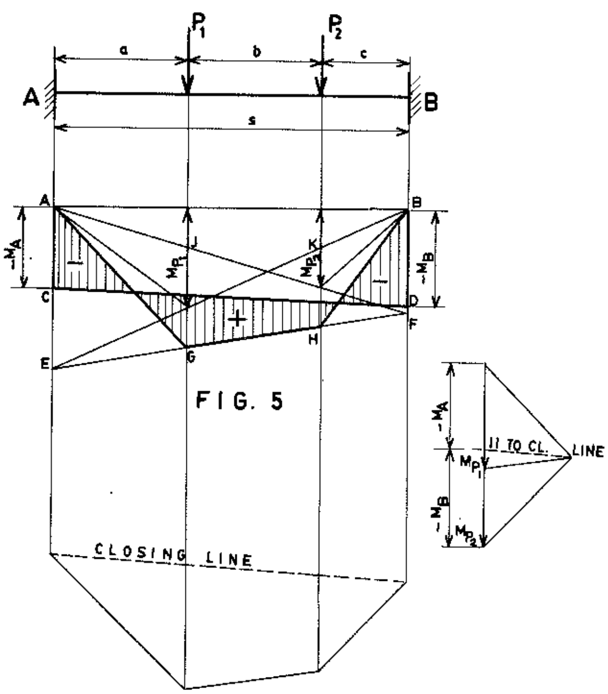


FIG. 5

FIG. 5a

3. Each of these altitudes may now be handled separately as shown in figure 3 and the 2 parts $(-M_A)$ and $(-M_B)$ added together at their respective locations. The closing line C-D completes the moment diagram for the fully fixed beam.

4. The two part-moment altitudes M_{P1} and M_{P2} may be considered as forces. A force diagram is drawn as shown in Figure 5a. The closing line of the resulting force polygon transferred back into the force diagram divides $M_{P1} + M_{P2}$ into $(-M_A)$ and $(-M_B)$.

With two forces on a simple supported span the moment diagram is a quadrilateral, or, in the case of 2 equal loads symmetrically arranged, a trapezoid. If each load is considered separately, the altitudes of the two moment triangles together are equal to the sum of the two fixed end moments if the beam is fully fixed.

The same principle also holds true for any number of concentrated loads on one span. The sum of the several altitudes of the part or component triangles is equal to the sum of the two fixed-end moments. This fact also proves to be a simple analytical solution: (See Figure 6).

$$(-M_A) + (-M_B) = \frac{P_1 a_1 b_1}{s} + \frac{P_2 a_2 b_2}{s} + \text{etc...}$$

$$(-M_A) = \frac{P_1 b_1^2 a_1}{s^2} + \frac{P_2 b_2^2 a_2}{s^2} + \text{etc...}$$

$$(-M_B) = \frac{P_1 b_1 a_1^2}{s^2} + \frac{P_2 b_2 a_2^2}{s^2} + \text{etc...}$$

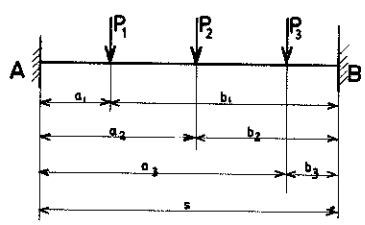
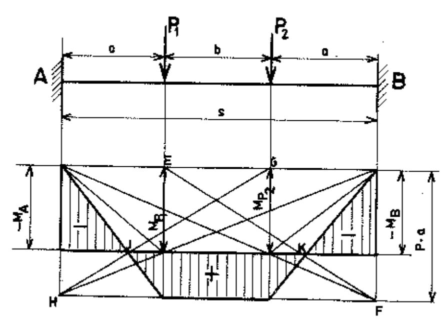


FIG. 6

Figure 7 shows the special case of 2 concentrated loads of equal magnitude arranged symmetrically.



$$-M_A = -M_B = M_{P_1} = M_{P_2} = \frac{Pa\,(a+b)}{s}$$

FIG. 7

---

* With only one diagonal: E-B produces altitude M_{P1} directly and M_{P2} equals K-H, or A-F produces altitude M_{P2} directly and M_{P1} equals J-G.

With more than two concentrations on a span, the extension of diagonals or circumscribing construction lines becomes an important exercise and the part-M-triangles are found as shown in Figure 8. The treatment of the M-altitudes as forces seems more efficient in this case than solving every triangle separately.

We first consider the beam "simply supported", construct a force diagram, and the resulting force polygon is our moment diagram.

Next we need the part moment altitudes M_{P1} to M_{P5} . Figure 8 shows a convenient procedure. If P_1 were the only force on the span, M_{P1} would be the altitude of the M-triangle. If P_2 were the only force, M_{P2} would be the altitude of the M-triangle and so on. The part-moment altitudes M_{P1} to M_{P5} in Figure 8 are then assumed as forces. A Force diagram is constructed and the closing line of the resulting force

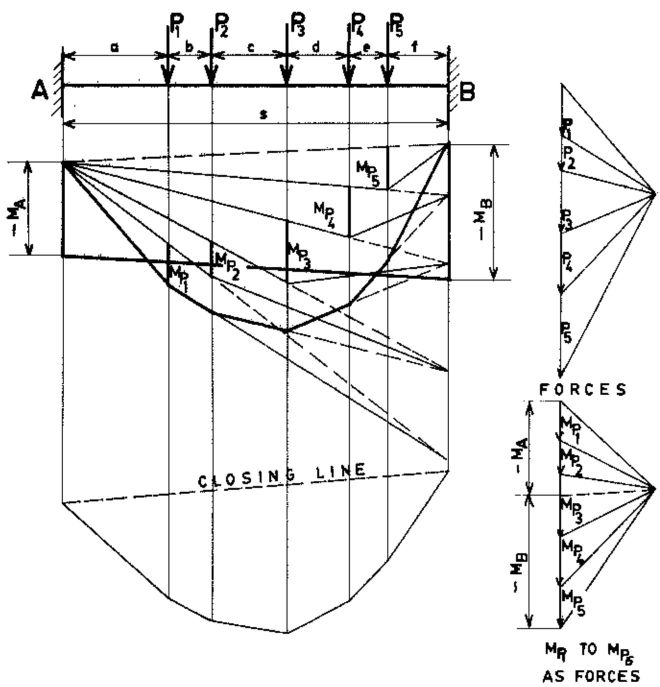


FIG. 8

polygon transferred back into the force diagram divides the sum of the part-moment altitudes into ($-M_A$) and ($-M_B$). These can be measured and placed in the proper location in the moment diagram which may now be completed by drawing the final closing line.

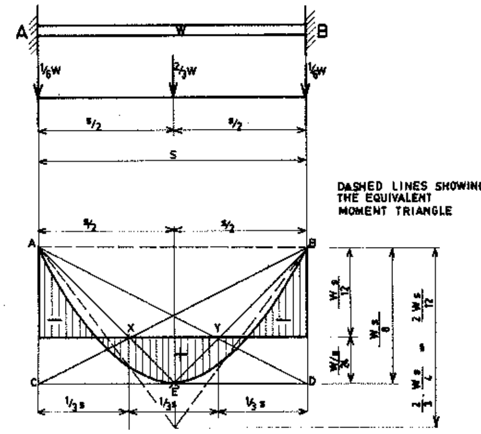


FIG. 9

The problems of uniform, partial uniform, triangular loading conditions and others may be solved by finding equivalent concentrated loads to be placed at such points as to produce the required M-altitudes. In Fig. 9 the known sum of the fixed-end moments $= \frac{2\ W\ s}{12}$. A single force in the center of the span to produce the same result:

$$\frac{2\ W\ s}{12} = \frac{X\ W\ s}{4} \quad ; \ X = \frac{2}{3} \ .$$

The single load in the centre of a uniform load is then $P = 2W/3$ and at the ends of the loading $P_1 = W/6$ each.

The forces at each end produce no moment if the load is over the whole span. They do however in the case of uniform loading over part of the span. (Figure 10).

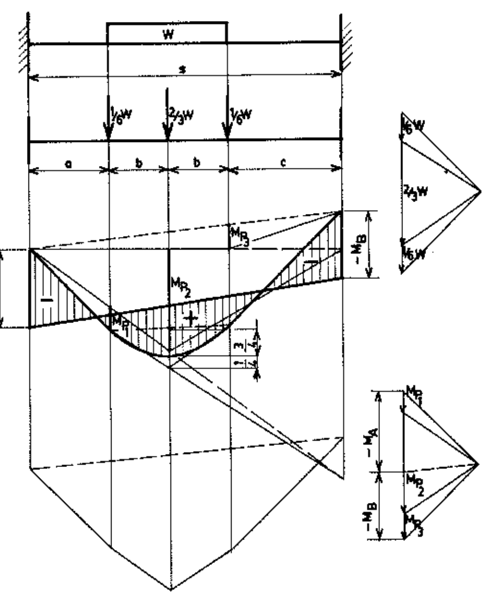
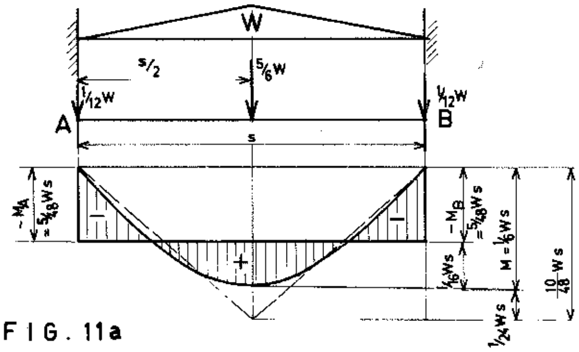


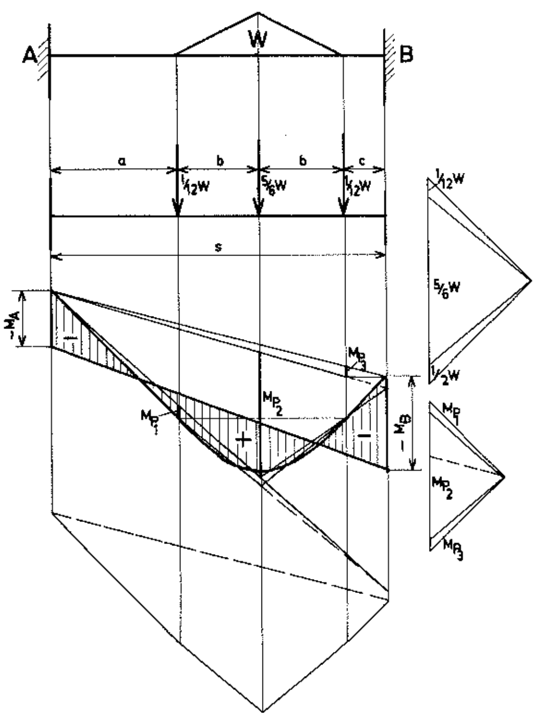
FIG. 10

The outer parts of the moment curve, from the ends of a partial uniform loading to the adjacent supports are straight lines; under the uniform loading the curve is a parabola. Figure 10 shows the uniform loading and its equivalent single loads which replace the uniform load. The concentrated loads on the span may then be solved as shown in Figure 8.



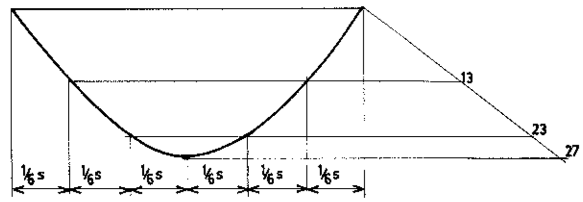
F I G. 11a

The loading condition shown in Figure 11a may be replaced by a single concentration of 5W/6 in the centre of the span.



F I G. 11b

Figure 11b shows the same kind of loading over part of the span only. The line of the moments is straight from the ends of the loading to the adjacent supports respectively.



F I G. 11c

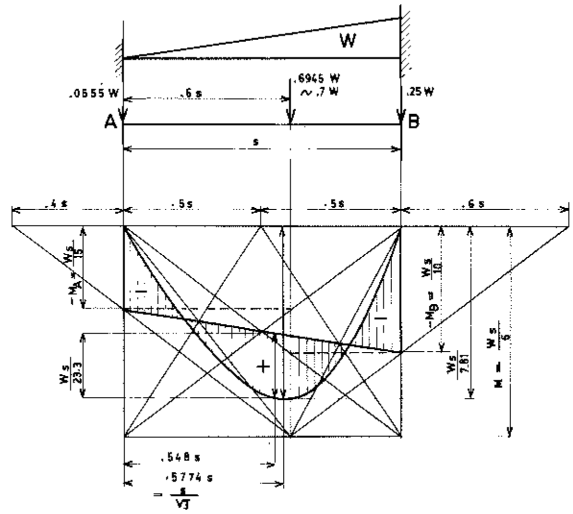
From Figure 12a it may be seen that if the graphical solution is to be applied to unsymmetrical triangular loads, a single concentration must be placed at 0.6 of the base length of the triangular load measured from the zero-end of the load because in the case of Figure 12a:

$$(-M_A) + (-M_B) = \frac{W\ s}{6} = \left(\frac{W\ s}{15} + \frac{W\ s}{10}\right).$$

$$\frac{W\ s}{10} = .6 \text{ of } \frac{W\ s}{6} \quad \text{and} \quad \frac{W\ s}{15} = .4 \text{ of } \frac{W\ s}{6}.$$

The single concentration at .6s would have to be:

$$\frac{X\ W\ .4s\ .6s}{s} = \frac{W\ s}{6}\ ;\ X = \frac{1}{1.44} = .6945.$$



F I G. 12a

$-M_A$ AND $-M_B$ ARE FOUND USING ANY OF THE CONSTRUCTIONS SHOWN IN FIGURES 3 AND 4 WITH A SINGLE FORCE OF .6945W AT .6s

The exercise becomes important in the case of Figure 12b because the mathematical solution is not as simple as in Figure 12a. In Figure 12b single substitute concentrations are required at the ends of the distributed load. Their magnitudes can be figured from Figure 12a, where for a simple supported beam the reaction at A = W/3 and at B = 2W/3. With .6945 at .6s away from 'A'

$$A = \frac{.6945\ W \quad .4s}{s} = .2778\ W\ .$$

The difference between .3333 W and .2778 W is .0555 W = the substitute single load to be applied at the zero-end of the triangular load.

$$B = \frac{.6945\ W \quad .6s}{s} = .4167\ W\ .$$

The difference between .6667 W and .4167 W is .2500 W = the substitute single load to be applied at the maximum end of the triangular load.

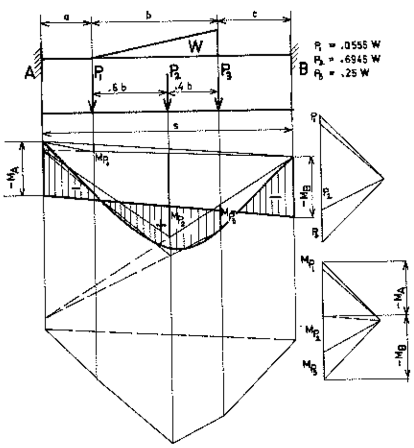


FIG. 12b

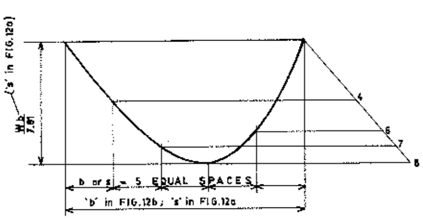


FIG. 12c

The line of the moments under the loading in Figures 12a and 12b follows the proportions shown in Figure 12c.

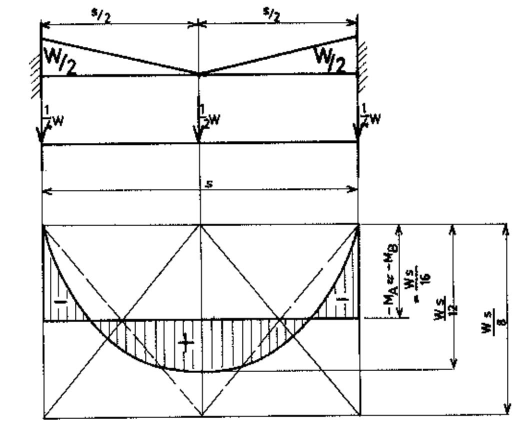


FIG. 13a

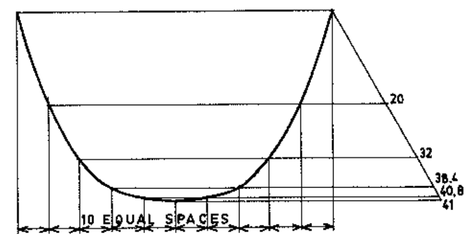


FIG. 13b

The loading conditions shown in Figures 13a and c may be solved as shown. The moment line follows a curve with the proportions shown in Figure 13b.

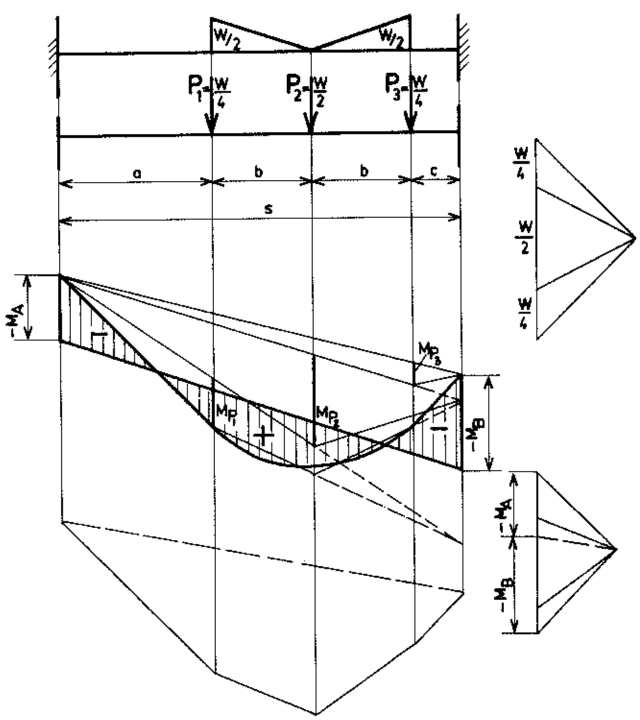


FIG. 13c

Any loading condition may now be arranged in sets of single concentrations and solved as shown in Figure 8. An example is shown in Figure 14.

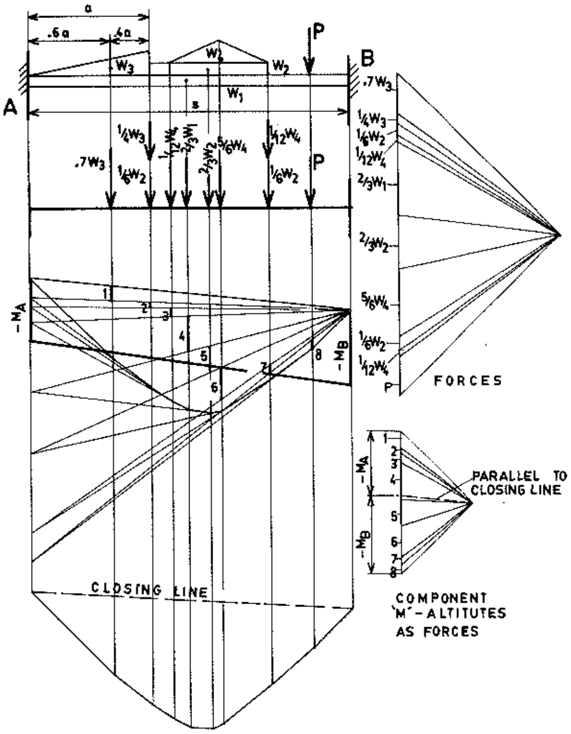


FIG. 14

Couples: After constructing the moment diagram (Figure 15) A-C-E-F, line C-E is extended to 'D' and 'B'. Triangle A-B-C establishes the positive component altitude G-C. Triangle D-E-F establishes the negative component altitude E-H. The two altitudes are shown as forces in the lower diagram: (G-C) minus (H-E). The closing line L-O in the force polygon is shallower than O-E thus indicating

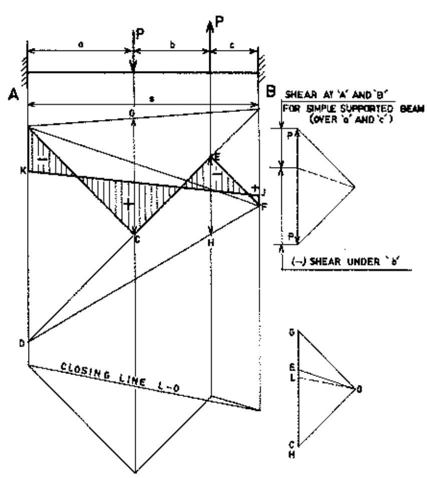


FIG. 15

that M_B is positive. If 'L' falls in between 'G' and 'E', both are negative. G-L in the force diagram is equal to A-K in the moment diagram which represents ($-M_A$), and L-E in the force diagram is equal to F-J in the moment diagram which represents ($+M_B$).

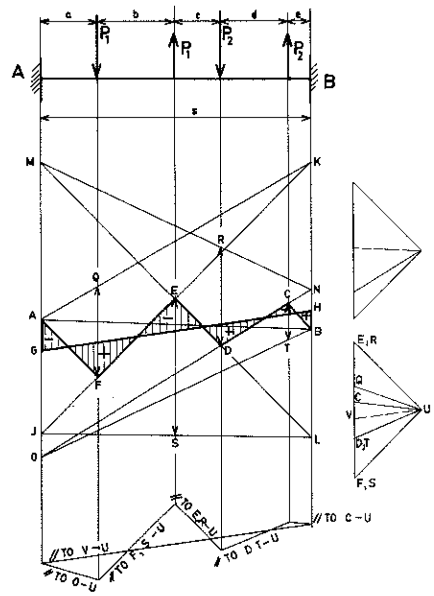


FIG. 16

As the couple moves closer towards 'B', M_B becomes negative reaching maximum with the uplift force directly over 'B'.

An interesting case provides the condition shown in Figure 16 with a pair of couples on one span. The moment diagram for the simple-supported span A-B-C-D-E-F-A changes signs three times. The altitudes of the component M-triangles are found by extending F-E to J and K, E-D to L and M and D-C to O and N. They are represented by Q-F (positive), S-E (negative), R-D (positive) and T-C (negative) in the force diagram. Starting with Q, the flow of forces in the diagram commences Q-F-S-E-R-D-T-C. The distance Q-V in the force diagram establishes the magnitude of ($-M_A$) and is transferred into the moment diagram represented there by A-G. The distance V-C in the force diagram establishes the magnitude of ($+M_B$) and is transferred into the moment diagram represented there by H-B. The distance Q-C in the force diagram is the sum of the altitudes of the component M-triangles for the simple supported beam which must be equal to the sum of the 2 fixed-end moments of the beam with fully-fixed end supports.

PUZZLE CORNER

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Below are two solutions which arrived after the fall issue went to press.

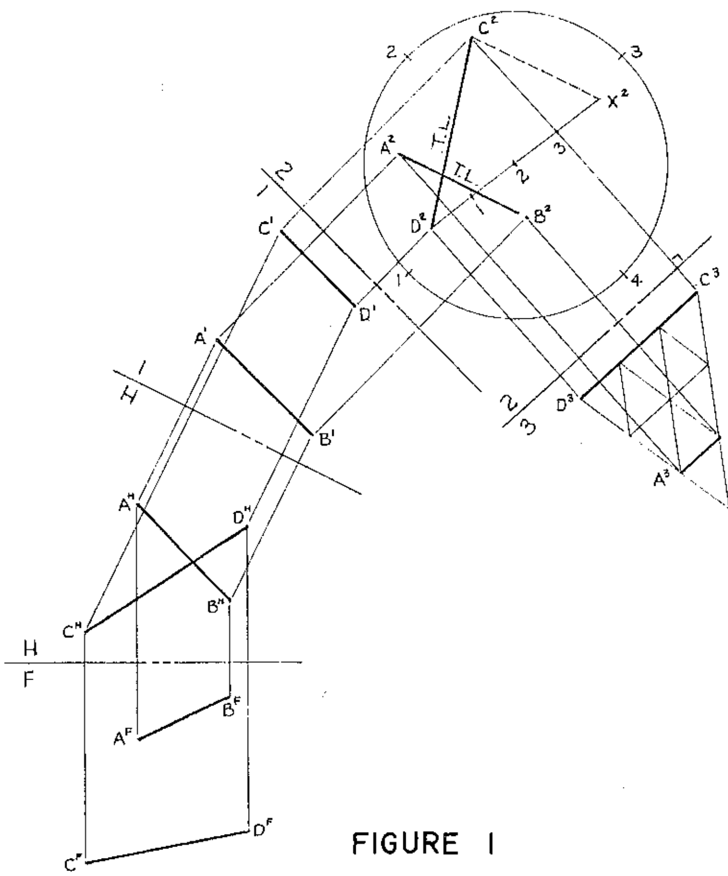
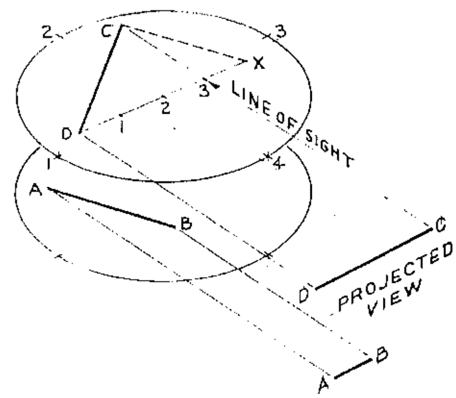
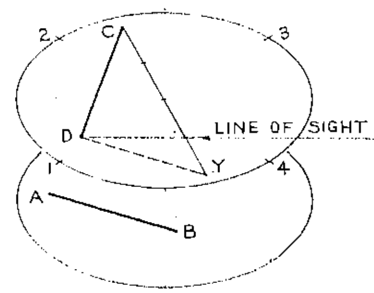


FIGURE I





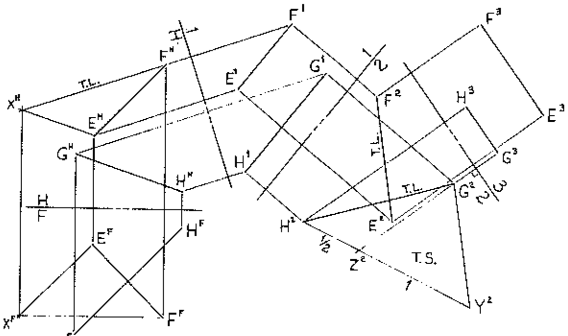


FIGURE 2

Figures 1 and 2 are from Walter N. Brown of Santa Rosa Junior College, Santa Rosa, California, and addresses the spring issue puzzle (which he also contributed):

Given: Adjacent orthographic views of two skew lines is general positions and of general lengths.

Determine: An orthographic view(s) such that the apparent lengths of the given lines are of a specified ratio (such as 1:½ as used in Walter's example below).

Walter's solution:

"(See Figure Two) Project a view where both lines are true length. Using one true length projection as one edge (G^2H^2), construct a true size plane which will have a second side (G^2Y^2) that is parallel to and equal in length to the other true length projection (E^2F^2). The third side of the plane is then divided into the desired proportions and a line is projected through this dividing point (Z^2) and the opposite corner of the plane (G^2). The fold line 2/3 for the desired projection is positioned perpendicular to this projected line (G^2Z^2) and the required view is projected in the third auxiliary view. Note that the proportions of projected lengths can be anywhere from 1:1 to 1:0 with the skewed lines taken in any order."

Figures 3-5 are another solution to our faithful friend the Perplexahedron. (See EDGJ, Vol. 43, No. 1 to Vol. 44, No. 3). They are from Dick Leuba of North Caroline State University and date to April 30, 1979, but were not in a form "intelligible to others" (Dick's description, not ours) until now.

Dick's solution (a quotation):

1. The Perplexahedron (EDG Journal, Winter 1979) is a multifaceted solid sided by eight, identical, 45° right triangles, Fig. 3. The object is to draw two principal views of the perplexahedron. Simple analysis reveals, however, that for a given length, AD, the essential dimension, m, is unknown, and without m the principal views cannot be drawn.

2. Because of symmetry, it is sufficient to analyze only two adjacent triangles to find m. The two selected are ABC and BCD in Fig. 3.

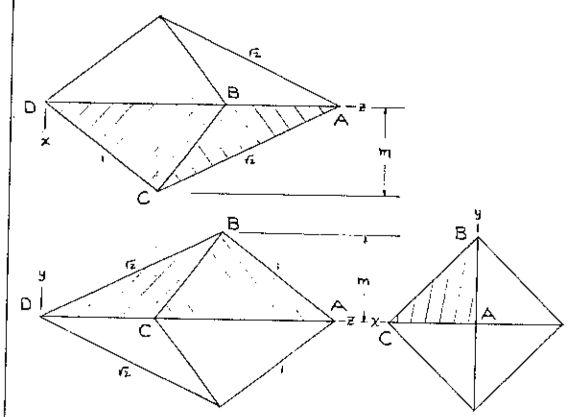


FIGURE 3

PERPLEXAHEDRON

3. Although the solution, Fig. 5, is accomplished conveniently in two orthographic views, the procedure, for convenience of illustration, is described referring to the isometric pictorial, Fig. 4.

4. In Fig. 4, two 45° right triangles (dashed lines), initially located in the Y-Z plane, have a common vertex, C'. This vertex, C', is progressively translated in the X-Z plane perpendicular to axis Z, until the "B" vertices, themselves tracing curves in the Y-Z plane, meet. (The whole concept is easily demonstrated, in 3-dimensional space, using mutually perpendicular planes and a pair of 45° triangles representing sides of the perplexahedron.)

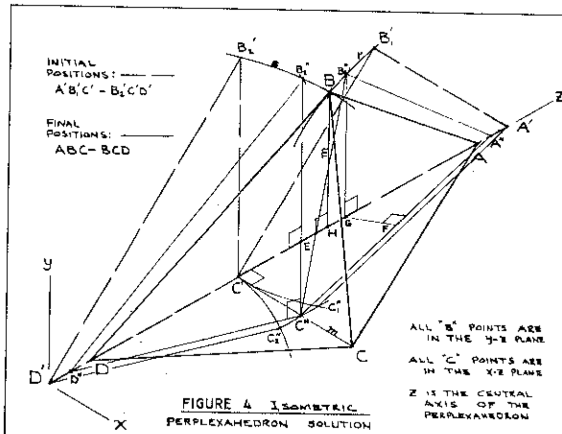


FIGURE 4 ISOMETRIC
PERPLEXAHEDRON SOLUTION

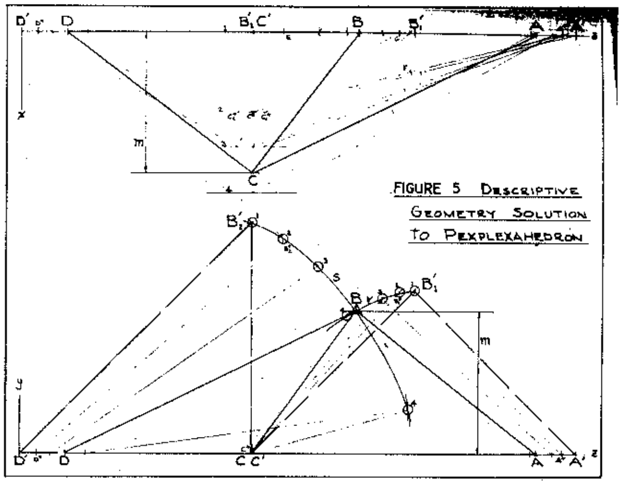


FIGURE 5 DESCRIPTIVE GEOMETRY SOLUTION TO PERPLEXAHEDRON

5. The trajectories of B_2'B and B_1'B, labeled r and s, respectively, cross at B. The distance BH is the sought dimension, m.

6. To illustrate in detail, triangles A_1B_1'C' and B_2'C'D' will be taken through one cycle, and a first pair of points, B_2" and B_1" will be found on trajectories s and r, respectively.

7. On plane X-Z rotate C' about D' an arbitrary distance to C_2". Next translate line D'C_2" in the Z direction until it assumes the position D"C". Draw the perpendicular from D"C", through C", in the X-Z plane, locating E on the Z axis.

8. On the Y-Z plane, find B_2" at the intersection of the perpendicular to Z from E and an arc of length D'B_2' (hypotenuse of the right triangle) with center at D". The triangle, originally at B_2'C'D', is now at B_2"C"D".

9. Next, reposition triangle A'B_1'C' by rotating C' in the X-Z plane about A' as center until C' reaches C_1" on an extension of the line C_2"C". Translate the line A'C_1", in the Z direction, to the position A"C".

10. Construct the perpendicular bisector of line A"C", giving FG. Locate B_1" at the intersection of the perpendicular from G, in the Y-Z plane, and an arc of radius A'B_1' (side of the right triangle) with center at A". Triangle A'B_1'C' is now at A"B_1"C".

11. Proceed in like manner, finding further points on the generated curves, r and s, until the curves intersect, Point B, Fig. 4.

12. The sought dimension, m, is the measured distance to the Z-axis, BH.

13. Due to symmetry, the distance C'C is another measure of m.

The procedure outlined above may be confirmed following the same points—many of them labeled—on the orthographic views of Fig. 5.

14. If the sides of the right triangles are assigned unit length, then m will measure 0.618....

15. Finally, knowing m, it becomes possible to correctly construct the principal views of the perplexahedron, Fig. 3.

In the meantime here's a filler:

Given: Four unlimited-length skew lines in general positions and specified as spherical tangents

Determine: The sphere defined by the given tangents.

'See you in the spring issue.

Pat

ANNUAL MEETING

MARGARET ELLER
LSU (RETIRED)
BATON ROUGE, LA

ENGINEERING -- INDUSTRY OR ACADEMIC?

A unique situation will take place during the week of June 21-27, 1981, when ASEE and SWE (Society of Women Engineers) will hold their annual conferences in Los Angeles. The University of Southern California campus will be the site of the ASEE conference the first part of the week, Sunday through Thursday; SWE activities will begin on Wednesday and continue through the following Sunday at the Disneyland Hotel. Not only will it be easier for those who belong to both societies to attend both conferences, but it is entirely appropriate that a joint meeting take place so that members who belong to only one of the societies can meet members of the other.

To that end, the Women in Engineering Committee of ASEE, and the Women in Academie of SWE have arranged a "meet and greet" event on Wednesday afternoon, June 24, 1981, at USC. Both of the sponsoring committees (WIE and WIA) have been active in Career Guidance and Professional Development, and both are involved in projects, in which joint effort might produce faster and easier, if not better, results. The event has also been endorsed, or co-sponsored by other committees and Divisions of ASEE: e.g. Relations with Industry, Liberal Studies, and Engineering Design Graphics. Attendance, however, is not limited to members of the sponsoring and co-sponsoring units.

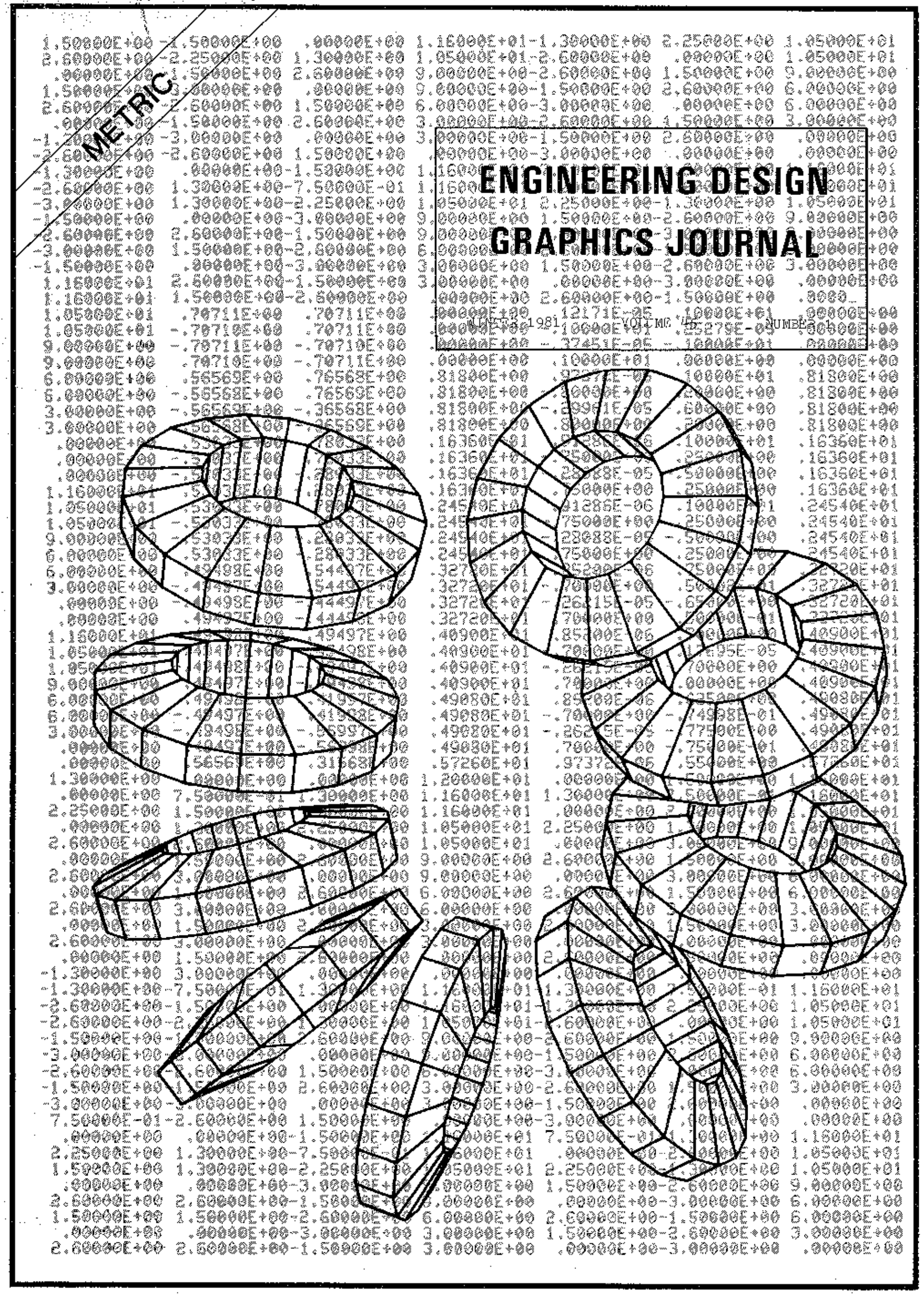
The program will consist of discussion led by experts on chosen topics, and attendees will be invited to participate in the program, as well as in the wine and cheese refreshment.

The scheduling of the two annual conferences during the same week in the same city is indeed unusual, and it may never happen again. For that reason alone, the situation should be recognized and celebrated by both societies.

MARGARET ELLER

The "Group Picture" - courtesy of LARRY GOSS -

EDGD Midyear Meeting
Williamsburg, Virginia
November 23-26, 1980



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